ANATOMY OF THE SPINE

HALLADAY

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D. J. Cooper

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APPLIED ANATOMY OF THE SPINE

BY

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DEDICATED

TO

MY STUDENTS

Whose appreciation of my work has been a constant source of inspiration

PREFACE

The introduction of the anatomical exhibit, an idea ingeniously conceived by Dr. H. V. Halladay and demonstrated by him and his assistants, as a feature of the program of the annual A. O. A. Convention, marked the beginning in osteopathic history of a new chapter, which each year opens up new vistas and shows that osteopathy, although in its infancy, is responding to the stimulus given it by such work as Dr. Halladay's.

The anatomical department of the A. O. A. Convention program, in charge of Dr. Halladay, had its inception at Columbus, Ohio, in 1917, when much interest was aroused in the unique dissections discussed in the series of lectures on Applied Anatomy given by him and his assistants. The following year at Boston, this department won further praise, but a grand climax was achieved at the 1919 convention in Chicago, when the anatomical exhibit consisted of a spine with all its articulations (vertebral, occipital, costal, and iliac) and ligaments intact and possessing the same movements and to the same degree as the spine of a living being.

To say that the exhibit at Chicago made a profound impression upon the profession is putting it mildly. The movements of the spine were so clearly demonstrated that one could see just what happened at a given articulation, thus affording a means of criticizing methods of spinal adjustment long in vogue and enabling the practician to visualize the lesion and to determine better the proper procedure for correction.

Looking at Dr. Halladay's work in retrospect, one sees that it has been evolutionary in character and that it has been developed with a certain end in view. This volume, Applied Anatomy of the Spine, is the logical outcome of the work of years, but it is not the end of that work—it is rather an earnest of further good things to come. It is what it purports to be, an applied anatomy of the spine, the subject being treated under the following subdivisions in connection with each articulation, namely: anatomy, movements, diagnosis, and structures affected. The real value of the work lies in the fact that it is the first osteopathic text (and we believe the first text of any kind) that describes the movements of each spinal articulation, giving the character and range of movement, and in which the statements made are based on laboratory findings. Heretofore it has been necessary for the osteopathic profession to accept almost without question the statements of medical text books as to the range and nature of spinal movements.

This is not meant to be a work on osteopathic technique, but to those who may be disposed to write on the subject of osteopathic technique, or to those who wish to develop and enlarge upon their technique, we would recommend this book as affording the most helpful basis that is available for such work. Moreover, to the busy practician this book should prove invaluable in aiding him to link up cause and effect, however remote, thereby facilitating diagnosis, and it therefore should occupy a prominent place in his reference library. To the undergraduate this book will be a boon inasmuch as it will enable him more readily to grasp the sig-

nificance of the spine and its related structures, and to understand the part faulty mechanics of the spine play in causing disease; in short, it will be of invaluable assistance to the undergraduate in correlating, classifying and applying the anatomical and osteopathic facts gleaned in the various departments and under the different instructors during his course in college.

There are some seventy illustrations in the book which assist materially in illuminating the text. These consist of drawings and photographs, the drawings being diagrammatic and both being designed to impress indelibly on the mind of the reader certain facts necessary to a thorough understanding of the subject under discussion. All of the drawings and photographs (with the exception of five or six drawings of the central nervous system) are original, none of them being copied from other texts, but being made from specially prepared subjects in the laboratory. A. G. WALMSLEY, D. O.

The preparation of anatomical material necessary to demonstrate the main facts as stated in this book was a time-consuming and tedious work. For this I am indebted to D. T. McGregor, H. I. Slocum, Clifford Ihde, John Halladay, Rufus Keithley, H. L. Davis and Miss Mary Cornforth. Without their able assistance the specimens could not have been prepared in the given time.

I am also deeply indebted to Dr. A. G. Walmsley and Miss Olive Moulton for the invaluable assistance rendered in editing the work, and for the many valuable suggestions and confirmations in parts of the book expressing absolutely new ideas.

H. V. HALLADAY, D. O.

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CHAPTER I.

THE OCCIPITO-ATLANTAL ARTICULATION

CLASS—DIARTHROSIS

SUBDIVISION—DOUBLE CONDYLARTHROSIS

This articulation consists of a pair of joints symmetrically situated on either side of the midline. The parts entering into their formation are the condyles of the occiput and the superior articular processes of the atlas. They are united by the following ligaments:

1. Anterior occipito-atlantal.
2. Posterior occipito-atlantal.
3. Two articular capsules.
4. Two anterior oblique.

The anterior occipito-atlantal ligament is a dense mass of fibers which is attached inferiorly to the anterior arch of the atlas and superiorly to the anterior border of the foramen magnum. This ligament is continuous laterally with the capsule of the articulation, the fibers of which overlap slightly. The central fibers are attached superiorly to the pharyngeal tubercle and inferiorly are continuous with the superficial part of the atlanto-axial ligament and then with the anterior common ligament of the vertebral column.

The posterior occipito-atlantal ligament is

broader owing to the greater length of the posterior arch of the atlas. It extends from the posterior arch of the atlas to the posterior margin of the foramen magnum between the condyles. Its lateral margins are thickened to form the oblique ligaments of the atlas, which extend from its posterior arch to the posterior margin of the articular process on either side. This is sometimes ossified, forming a foramen for the passage of the vertebral artery and first cervical nerve. The articular capsules are lax but strong except for their inner surface. They are attached above to the margins of the condyles of the occiput and below extend a short

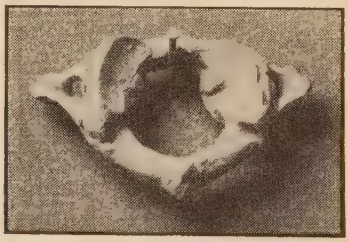


Fig. 1. Superior surface of Atlas. Note variation in length of transverse processes.

distance below the margins of the articular processes of the atlas. Anteriorly and posteriorly they blend slightly with the anterior and posterior occipito-atlantal ligaments.

The anterior oblique ligaments are accessory bands which strengthen the articular capsule on the outer side and extend from the upper surface of the transverse process to the jugular process of the occiput.

The blood supply is derived from the vertebral, occipital, ascending pharyngeal and ascending deep cervical arteries.

The articulation receives its nerve supply from the first cervical segment.

Movements

1. Flexion and Extension.
2. Lateral Flexion and Rotation combined.

Flexion and extension represent the characteristic movements of the articulation, occurring through a possible range of twenty-five degrees, the fixed point being found at the center of the constricted area of the articular surfaces of the atlas. In examining the position of the ligamentous and bony parts in extreme flexion the posterior occipito-atlantal ligament is stretched and the anterior occipito-atlantal ligament is relaxed. The condyles of the occiput have moved posteriorly on the articular surfaces of the atlas. The chin will be lowered in this position. In extreme extension the posterior occipito-atlantal ligament will be relaxed, the anterior occipito-atlantal ligament will be tense and the chin will be raised. The condyles of the occiput have moved forward on the articular surfaces of the atlas. Flexion past a certain degree will be prevented by the approximation of the styloid processes and their attached tissues to the transverse processes of the atlas and their attached tissues. Extension is limited by the approximation of the posterior arch of the atlas to the occiput.

Lateral flexion and rotation are combined, that is, where we find lateral movement there is

ALWAYS in conjunction with it a small degree of rotation. This movement is not the characteristic movement of the joint, as are flexion and extension, but may be effected through the contraction of the

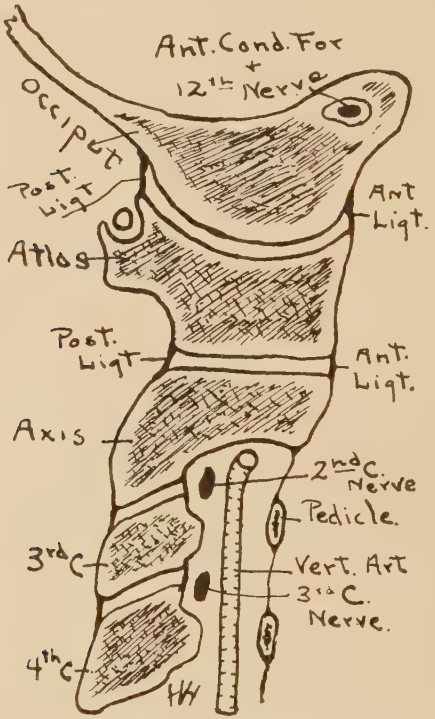


FIG. 2. A drawing from a laboratory specimen, the section being made parallel to the sagittal plane and through the condyles of the occiput.

lateral muscles connecting the occiput and the atlas. It is also to be noted that this movement, lateral flexion and rotation, is greater in extension than in flexion. This is explained by the extreme tension

on the posterior occipito-atlantal ligament, the approximation of the styloid process to the transverse process of the atlas, and the depth of the condyles of the occiput with relation to the articular surfaces of the atlas. Rotation as an independent movement is not present. It is found only as above described, associated with lateral flexion.

Diagnosis

In palpating for movement in this articulation, it is well to keep in mind that we must allow for certain anatomical abnormalities as short or long transverse process of the atlas and also, as sometimes found, a variation in the mastoid process of either side. When one transverse process is longer than the other the long transverse process may, because of being more prominent, mislead the diagnostician and cause him to say there is a misplacement when one does not exist. These are, however, fixed points and, regardless of variation, are the ones to be used in palpation and diagnosis of lesion.

Flexion.—In flexion, the transverse process of the atlas will be found to be separated from the mastoid process of the temporal bone and approximated to the angle of the mandible.

Extension.—In extension, the transverse process of the atlas will be approximated to the mastoid process of the temporal bone and separated from the angle of the mandible.

Lateral Flexion and Rotation.—In lateral flexion and rotation, if to the right, the transverse process of the atlas on the right will be separated from the mastoid process of the same side, and on

the left side the transverse process of the atlas will be approximated to the mastoid process. This gives us a condition simulating rotation as an independent movement, but by more attention to the detail of the position of the structures it is noted that the transverse process on the left side is slightly more prominent than that on the right. Slight

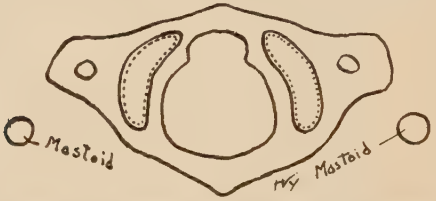


Fig. 3. Showing the normal relative position of the mastoid process and the transverse process of the atlas. The position of the condyles of the occiput is indicated by dotted lines.

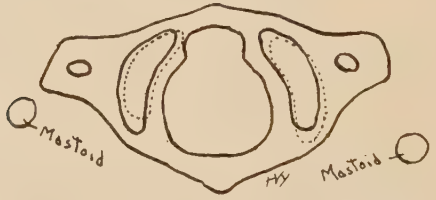


Fig. 4. Showing relative position of the condyles of the occiput and mastoid processes to the atlas in lateral movement to the right. Position of condyles indicated by dotted lines.

extension is possible in this position, but flexion is prevented by the tension on the capsular and posterior occipito-atlantal ligaments.

Structures Affected

In considering the effects of any abnormality of this articulation, each tissue affected should be

considered, as we rarely find impairment of function of one structure alone.

Bone.—Laboratory findings in chronic lesions show in every case exostoses varying with the extent of the lesion and the length of time it has been in its abnormal relationship. In the case of the occipito-atlantal articulation the margins of the condyles of the occiput show irregular growths, especially anteriorly and posteriorly. The margins of the articular surfaces of the corresponding atlas show an irregular margin which is slightly folded upon itself.

Ligaments.—When a ligament is put on tension for a time, it is at first somewhat thinner, but if the tension be continued, compensation will take place and thickening occur. Thus we find in some cases a slight difference in the density of the ligaments resulting from lesions of this joint. This explains the impaired motion and the difficulty of reduction as found in many cases.

Muscles.—Whether the articulation be held in flexion, extension or lateral flexion and rotation, the small muscles that move this articulation will be affected. Posteriorly we find the posterior recti, laterally the rectus capitus lateralis and anteriorly the anterior recti. The posterior recti are easily palpated and tenderness varying with the degree of impairment will be noted.

Arteries.—The vertebral artery passes from the sub-occipital region to the cranial cavity lateral to the posterior occipito-atlantal ligament. In some cases the oblique portion of the posterior ligament is ossified and serves as an excellent pro-

tection for the artery, but in the most of the cases examined this is merely a thickened ligament and an intimate part of the posterior ligament. The artery in such cases could easily be partly compressed and its function impaired by lesions affecting the posterior ligament. In this region there occurs a free anastomosis of the vertebral, occipital and ascending deep cervical arteries, the small anastomosing branches of which may be affected by contractured muscles in this region.

Nerves.—The first cervical nerve leaves the cord, passing out of the spinal canal between the

FIG. 5. Indicating the position of the first cervical nerve in relation to the lateral mass and transverse process of the atlas, and vertebral artery.

atlas and occiput and in relation to the vertebral artery. Normal physiological movement will not irritate this nerve, but if the normal movement be disturbed and congestion and undue pressure result in this region, we note the effect upon the various functions associated with this segment. (1) Cutaneous. Very little cutaneous disturbance results from direct pressure on this nerve, but on account of its frequent association with the second segment through a loop of communication, pain is often referred to the back of the head. (2) Voluntary impulses. This segment innervates the posterior recti muscles through its posterior primary division, the

sub-occipital nerve, and will result in contractured muscles in the region. Through its anterior primary division it innervates the anterior recti group and assists in the innervation of the infrahyoid muscles. This division being irritated will produce laryngeal symptoms through the tipping of the hyoid and resulting irritation to branches of the vagus in relation to that bone. (3) Involuntary. This segment communicates with the superior cervical ganglion of the lateral chain and with the vagus nerve, consequently we note in some cases disturbed function of the vagus and congestion in the region of the head, due to reflexes through the lateral chain affecting the blood supply of cranium and face, which is controlled by the superior cervical ganglion.

Movement.—Impairment of movement is one of the first indications of lesion of this articulation. Palpation should be made carefully and correctly, taking every factor in the discussion of the joint into consideration. This articulation may be the primary seat of lesion, but may also be secondary, and in all cases thoro examination of the entire spine should be made so as to determine the possibility of this articulation attempting to compensate for a lesion below.

CHAPTER 11.

THE ATLANTO-AXIAL ARTICULATION

In order to describe properly the articulations between the atlas and axis, they will have to be divided into two parts, namely, the lateral atlanto-axial articulations and the central atlanto-axial articulation. The lateral articulations are found between the inferior articular surfaces of the atlas and the superior articular facets of the axis, and the central articulation is between the odontoid process of the axis and the anterior arch of the atlas. Connecting the two bones are the following ligaments:

(1) Anterior atlanto-axial.
(2) Posterior atlanto-axial.
(3) Articular capsules for each lateral joint.
(4) Transverse ligament.
(5) Atlanto-odontoid articular capsule.

The anterior atlanto-axial ligament is a narrow, but strong connective tissue membrane found anteriorly between the lateral articular capsules and attached above to the lower border of the anterior arch of the atlas. Below it is attached to the transverse ridge on the anterior surface of the body of the axis. It is in reality a continuation of the anterior common ligament of the spine and some of its

fibers, especially those in the midline, may be traced to the anterior margin of the foramen magnum of the occiput.

The posterior atlanto-axial ligament is somewhat thinner than the anterior, and is broader. It extends laterally from the posterior surface of the root of the transverse process of one side to the same point on the opposite transverse process. Superiorly, it is attached to the inferior margin of the posterior arch of the atlas, and inferiorly to the superior margin of the lamina of the axis on the dorsal surface. It is similar in position and function to the ligamenta subflava and contains elastic tissue.

The lateral articular capsules are attached to the margins of the articular surfaces of the lateral joints and are of sufficient length to allow of free motion between the two bones. They are strengthened anteriorly and posteriorly by the anterior and posterior ligaments, and laterally are stronger than on the inner surface which is in relation to the spinal canal.

The transverse ligament is an exceptionally strong mass of fibers extending from a tubercle on the inner side of the lateral mass of the atlas across (posterior to the odontoid process) to a similar attachment on the opposite side. It thus separates the odontoid process from the spinal canal, and serves as the supporting ligament in maintaining the position of the odontoid process and its relation to the atlas. It is crossed posteriorly by vertical fibers, extending from the body of the axis to the inner surface of the foramen magnum and which, together with the transverse ligament, form

a cross which is referred to as the crucial ligament.

The articular capsule of the central articulation is a dense mass of fibers, extending completely around the articulation between the atlas and the odontoid process. Laterally, these fibers blend with the capsules of the lateral articulations and above and below with the anterior atlanto-occipital and atlanto-axial ligaments.

A double synovial membrane is found at the central articulation, one between the odontoid process and the anterior arch of the atlas, and the other between the transverse ligament and the odontoid process. The latter may communicate with the lateral articulations. The blood supply is from the vertebral artery, and the nerve supply from the second cervical nerve.

Movements

Rotation.

Flexion and Extension.

Rotation is the characteristic movement of this articulation, the axis of rotation being through the center of the odontoid process. This movement occurs in practically a horizontal plane and through a possible range of 90 degrees. It is checked by the alar ligaments and by the articular capsules. Examining the articular cartilages of the joint, we find that they are convex on the surface, so that in any position of rotation only a small part of each cartilage is in contact with the one above or below. Thus, in the rotary movement the bones themselves are approximated slightly, this arrangement allow-

ing for more freedom of motion and, at the same time, maintaining the security of the joint.

Flexion and extension, or movement in the sagittal plane, is limited. The joint is so constructed anatomically that this movement is limited for physiological reasons. The range of movement is between 5 and 8 degrees; if more, injury may result; if less, no harm can be done. Forward-bending is limited by the odontoid process, pressing against the transverse ligament. Neither the mus-

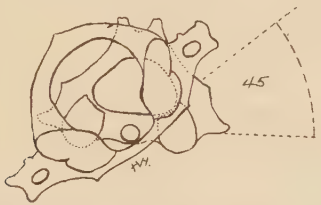


Fig. 6. Showing the range of movement possible between the atlas and axis. Note the relative position of the spinous process of the axis to the transverse processes of the atlas.

cles nor other ligaments, except the transverse, will affect the extent of this movement unless the transverse be destroyed. Backward-bending is limited by the approximation of the posterior arch of the atlas to the superior border of the lamina of the axis.

Diagnosis

In palpating for movement in this articulation, we must choose some points on each bone that will be easily found and are usually symmetrical. For this purpose, we can use the transverse pro-

cesses of the atlas and the spine of the axis, although it must be kept in mind that there are variations of each of these, and allowance must be made for variations. Especially is this true of the spine of the axis, it being bifid, and frequently the division on one side is much longer and more easily palpated than that on the other. Thus, measurements from one to the other would not suffice. The actual amount of movement must be judged by the operator in the palpation.

Rotation is easily determined. On the side to which the face is turned there will be an approximation of the transverse process of the atlas to the spine of the axis, and on the opposite side an equal amount of separation. With the face forward, the distance between these parts should be the same, there being neither an approximation nor a separation, allowing for the variation mentioned above.

By deep palpation, the posterior arch of the atlas may be located and this, together with the spine of the axis, may be used to determine the flexion and extension. This movement is not the characteristic movement of the articulation, and it is not so important to determine it accurately. However, there should be some movement here, and complete loss of this antero-posterior movement indicates a lesion.

The rotary movements are limited in flexion and extension, so, in palpating for the rotary movement it is best to have the articulation in a position of rest as nearly as possible.

Structures Affected

Laboratory findings in connection with this articulation show many abnormalities, especially of the bony structures.

Bone.—The odontoid process varies in length, sometimes extending to the margin of the foramen magnum, and even in a few cases showing evidence of the formation of an articulation there. This abnormality is associated with flexion lesions of the occipito-atlantal articulation. Exostotic growths are noted on the articular surfaces of the lateral articulations, and are associated with lesions of the occipito-atlantal articulation, evidently the result of an attempted compensation. The articular facets vary in size, which indicates a possibility of more movement on one side than on the other. Ankylosis is rare and when it occurs is associated with a similar condition found in other parts of the spine.

Ligaments.—Variations of the ligaments have been noted. Ossification of the transverse ligament is not uncommon. A condition of this kind would limit the amount of flexion or extension, but not in any way interfere with rotation. Partial ossification of the central portion of the posterior atlanto-axial ligament has been found a number of times, possibly indicating an attempt on the part of nature to limit motion. Lax ligaments are commonly found, in fact there can be sufficient relaxation of the capsular ligaments to allow of dislocation of the joint without fracture of any of the bony parts.

Muscles.—Movement of the joint is very often limited on account of the contracture of one or

more of the muscles associated. We see the effect on the articulation when there is contraction of the various muscles, extending from the upper thoracic region to the head, and from cervical spines to the transverse process of the atlas. Those producing rotation are mainly the sterno-mastoid, trapezius, levator angulae scapulae, obliquus capitus inferior, splenius cervicis and capitus.

Arteries.—The only large artery in relation to the articulation is the vertebral. In passing from the vertebral foramen in the transverse process of the axis to that of the atlas, it must pass outward on account of the difference in the length of the transverse processes. It is very tortuous in this part of its course, in order to allow for free rotary movement without injury to its walls. Except in extreme lesions, there is very little chance of injury to this artery, but it may be interfered with due to

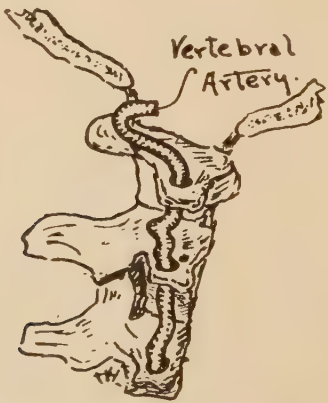


Fig. 7. The vertebral artery passing through the upper cervical transverse processes and the posterior occipito-atlantal ligament.

extreme tension on the joint thru a disturbance of its nerves, which follow with it into the cranial cavity. Venous congestion is common in this region, due to the free anastomosis of the vertebral vein with other veins, but is relieved by relaxation of the musculature, which is more often in lesion than the articulation in question.

Nerves.—The second cervical nerve makes its exit from the canal between the atlas and axis and posterior to the lateral articulations. It first perforates the posterior atlanto-axial membrane, rest-

FIG. 8. Indicating the position of the second cervical nerve in relation to the upper surface of the axis and the vertebral artery.

ing upon the upper surface of the axis or the superior border of the base of the lamina. The anterior primary division passes posterior to the vertebral artery and assists in the formation of the cervical plexus. The posterior primary division passes beneath the obliquus capitus inferior, turns upward and after perforating the muscles attached to the head, supplies the scalp, and is known as the great occipital nerve. On account of following the movements of the axis rather than the atlas, there is very little chance for disturbance of the nerve in all normal movements of the joint, but in extreme ex-

tension or rotation past the normal range of movement the nerve will be disturbed. Cutaneous irritation may result over the areas supplied by the great occipital, small occipital, great auricular and transverse cervical, as each has its origin partly or wholly from this segment. Voluntary motor impulses to the infra-hyoid group and to the anterior, lateral and posterior deep muscles may be interfered with. The segment is also associated with the vagus, and a reflex may be noted over it. The superior cervical ganglion of the lateral chain is connected with the segment, and rests in intimate relation to the transverse process. In consequence of this latter relationship, there may be disturbance of the various impulses carried from or thru the ganglion.

Movement.—Any variation from the normal movement should be considered a lesion of this articulation. Irritation to the surrounding structures may be the result of too free movement, or of loss of motion. Special care should be taken in testing for movement that the lower cervical segments are not allowed to take part in the rotation. Movement may be limited or free, as the result of compensatory lesions above or below, and this must be taken into consideration. Any movement which requires extreme flexion or strain on the transverse ligament should be performed with great care, as there may be rupture of the transverse ligament or fracture of the odontoid process, either of which will result in injury to the spinal cord.

CHAPTER III.

THE TYPICAL CERVICAL REGION

In order to understand the typical movement in the cervical region, it will be necessary to describe the typical cervical vertebra and note its variations from the dorsal and lumbar vertebrae.

The body of the cervical vertebra is smaller than that of other regions and is oval in shape, the long axis being transverse. The upper surface is convex antero-posteriorly and concave transversely, making the articulation between the bodies similar to a saddle joint. The pedicles are attached to the

FIG. 9. A typical cervical vertebra.

body near its center and are directed laterally and posteriorly. The attachment to the center of the body forms the intervertebral foramen from equal parts of the vertebrae above and below. The spines are very irregular, the most of them being bifid.

That of the axis is large and prominent, being easily palpated. Those of the 3rd, 4th, 5th and 6th are smaller, very irregular, one point being often longer than its fellow, and are not easily palpated in extension. The spine of the 7th is very prominent and is called the vertebra prominens. It is not often bifid and resembles more closely the upper dorsal spines than the cervical spines.

The articular processes are important parts of the cervical vertebra. The inferior articular processes are easily palpated and their articular surfaces are directed forward and downward. The superior articular surfaces are directed upwards and backwards.

The transverse processes are directed forward and present two tubercles: the anterior, representing the costal portion of the process; and the posterior tubercle, the true transverse process. Each process in the cervical region is perforated by the vertebral artery and vein, with the exception of the 7th, which transmits the vein only.

The typical articulations in the cervical region are found to be similar to those found in the dorsal and lumbar regions, that is, there will be two classes: one found between the bodies of the vertebrae, and the other between the articular facets. Also, the ligaments binding these articulations together are similar in all regions. For convenience, then the following description of the above parts will apply to the various regions, and as variation in movement occurs, it will be noted with that particular region.

The Articulations.

Synchondrosis, between the bodies and intervertebral discs.

Arthroidal, between the articular facets.

The Ligaments:

Intervertebral fibro-cartilage.

Anterior longitudinal.

Posterior longitudinal.

Articular capsules.

Ligamenta flava.

Supraspinous ligament.

Interspinous ligament.

Inter-transverse ligament.

The intervertebral fibro-cartilages are tough, but elastic and compressible discs, which serve as the main connecting structure between the bodies of the vertebrae from the axis to the upper surface of the sacrum. Each is composed of two parts. The outer part consists of layers of fibrous tissue and fibro-cartilage, the fibers passing in oblique and vertical directions from the lower surface of the body of one vertebra to the upper surface of the body of the vertebra below. The central portion is pulpy and forms a ball of tightly compressed and elastic tissue and thus exerts pressure in all directions on the adjacent structures. On account of its shape and composition, it forms a ball upon which the bodies of the vertebrae may rotate or bend in the various directions.

The anterior longitudinal ligament begins as a narrow fibrous band attached to the inferior surface of the occiput in the midline anterior to the anterior occipito-atlantal ligament. It continues

as a narrow band to the body of the axis, where it becomes broader, and, as it descends, gradually increases in width until in the lumbar region it is almost two inches in width. Inferiorly, it is fixed to the anterior surface of the sacrum and blends with the periosteum about the center of the bone. It is firmly attached to the bodies of the vertebrae over which it passes.

The posterior common ligament extends from the base of the occiput to the coccyx. It is narrow and of almost uniform width throughout its extent. This ligament is found attached to the posterior surface of the bodies of the vertebrae inside the spinal canal and is firmly attached to the vertebrae and the intervertebral discs, there being a lateral expansion present at each disc.

The articular capsules which unite the articular processes and enclose the synovial cavity of the lateral articulations are composed of fibroelastic tissue. The fibers are in the main longitudinal, but in the lumbar region most of them are oblique. The articular capsules are most lax in the cervical region, less so in the lumbar, and tightest in the dorsal.

The ligamenta flava are composed of yellow elastic tissue and are found between the laminae of two adjacent vertebrae. Laterally, each ligament extends to the posterior margin of the intervertebral foramen. Superiorly, it is attached to the inner surface of the lamina, and inferiorly, to the outer surface of the lamina below. These ligaments assist in completing the spinal canal posteriorly.

The supraspinous ligament extends from the external occipital protuberance along the tips of the spinous processes to the periosteum, covering the posterior surface of the coccyx. In the cervical region, it varies, being formed of a main mass of longitudinal fibers extending from the external occipital protuberance to the spine of the 7th cervical vertebra. However, each spine in the cervical region is connected with the main ligament by a series of fibrous processes radiating fan-like from the tip of the spine to the anterior surface of the ligament. Its posterior border is thickened to serve as the attachment for the superficial cervical muscles In the dorsal and lumbar regions, it is attached to each spine and also serves as the partial origin for muscles. The interspinous ligaments are thin fibrous membranes extending between the spines. In the cervical region they are replaced by the interspinales muscles, but in the dorsal and lumbar regions are more prominent.

The intertransverse ligaments represent in reality the fibrous sheath of the intertransversales muscles. In the various regions they may replace entirely the intertransversales muscles. When found as a separate structure, they are attached to the tips of the transverse processes.

Movements

(1) Flexion and Extension.

(2) Lateral Flexion and Rotation combined.

Flexion in the typical cervical articulations is a well-defined movement. Normally, there is present a cervical curve the convexity of which is directed

forward. This can be eliminated by forward bending. Flexion is, however, not evenly distributed. An examination of the disc between the 2nd and 3rd cervicals will show that it is very thin in comparison with the others, and it will also be noted that the anterior margin of the lower border of the body of the axis is prolonged to form a projection of bone that limits forward-bending. This does not occur normally on the remaining cervical vertebrae, but

Fig. 10.. Flexion of the cervical region. Note that the cervical curve is obliterated.

is found occasionally in the laboratory extending to the two articulations below, but not so marked. Extension is a free movement and is limited only by the approximation of the spines. Altogether the range of movement in the typical cervical articulations is through an arc of about sixty degrees. In noting the position of the structures in flexion, we find the supraspinous, intraspinous, ligamenta flava, articular capsules and posterior common ligaments stretched and the spinous processes separated. The inferior articular facets have moved forward and upward upon the superior articular

facets of the vertebra below. There is compression of the intervertebral disc anteriorly and stretching of it at its posterior margin. In extension there will be relaxation of the supraspinous, interspinous, ligamenta flava, articular capsules, and posterior common ligaments, with stretching of the anterior common ligament; the spinous processes are approximated. The inferior articular facets have moved downward and backward upon the superior articular

Fig. 11. Extension in the cervical region. Compare with figure 13.

facets of the vertebra below. There will be compression of the intervertebral disc posteriorly and stretching of it anteriorly together with stretching of the anterior common ligament.

In lateral flexion and rotation, we find a movement that if properly analyzed will be seen to be a combination of flexion and extension. Laboratory tests have determined the following facts which will apply to the typical cervical articulation: If the side-bending be to the right, the body of the vertebra is turned slightly to the right, the fibers of the anterior common ligament are directed down-

ward from the right to the left, there is compression of the intervertebral disc postero-laterally on the right, the inferior articular facets on the right have moved downwards, backwards and slightly inwards, the right portion of the ligamenta flava is relaxed, the spine of the vertebra is turned to the left, the supraspinous ligament being directed obliquely downward from left to right, the left ligamenta flava is stretched, the inferior articular facet on the left has moved upward, forward and slightly outward on the superior articular facet below, and the intervertebral disc is relaxed antero-laterally on the left. Comparing the above with the position of the structures in flexion and extension, it will be seen that the left side is in a position of flexion and the right side in a position of extension, with this addition, a certain amount of rotation of the body of the vertebra has occurred. On account of the shape of the articular facets, side-bending or lateral flexion must be accompanied by some rotation, and vice versa. However, in the cervical region the side-bending is greater in proportion than the rotation. This movement occurs most freely in the position of rest, and is limited by flexion or extension. At the extreme of either flexion or extension, lateral flexion and rotation cannot occur without marked injury to the ligaments or bony structures. In extension it is prevented by the approximation of the inferior margins of the articular facets, and in flexion by the tension on the articular capsules.

Diagnosis

In palpating for movement in the cervical region, it is necessary that we choose some bony

prominence that will present the fewest possible variations and yet be easily found. The spinous process is the most easily palpated part of the vertebra, yet, on account of being bifid and varying in length, they will not serve for all movements. We may, however, use the spinous process in determining the approximate amount of flexion and extension, as we find them to be separated in flexion and approximated in extension. It would then be true, when it was discovered, in putting the cervical region through these movements, that any two spinous processes remained in the same relative position to each other, there must be limited movement in the sagittal plane. It should be noted that, in flexion, the spinous processes are easily palpated; in extension, they seem to have disappeared. This leads to the conclusion that, when we find a case in which the spinous process is prominent and is separated from its fellow below, the articulation is held in a position of forward bending, and, on account of being prominent, has, in the past, been spoken of as being posterior. We note also that, in extension or backward-bending, the spinous processes are difficult to palpate, and we find an instance where the spinous processes of one vertebra is apparently deep in the tissues and at the same time approximated to the one below; this articulation is held in a position of extension and is often referred to as being anterior. The terms "anterior" or "posterior" should not be applied to such conditions. An examination of the cervical region, or, for that matter, the dorsal or lumbar region, will reveal the fact, that, if a verte-

bra is anterior, it must be anterior on a plane passed through its intervertebral disc. If this occurs, there must be fracture of either the inferior articular facets of the vertebra above, or of the superior articular facets of the one below. In the prepared spine, a vertebra may be thrust posteriorly in the plane of its intervertebral disc, but, upon the re-

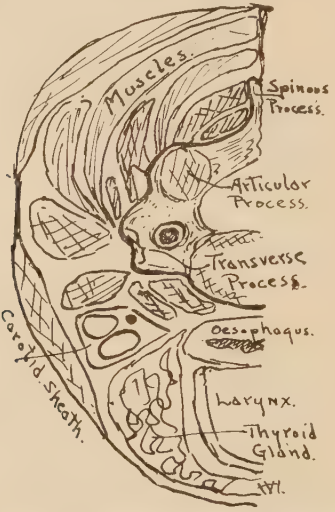


FIG. 12. One half of a transverse section of the neck showing the depth of the spinous process, articular process and transverse process. Taken from a laboratory section.

lease of the pressure, will assume its normal position. Lesions, referred to (in the past) as posterior, are in reality forward-bending or flexion lesions, and those referred to as anterior lesions are backward-bending or extension lesions. The latter terms (flexion and extension) describe the movements in which the lesion occurred. We may, then,

use the spinous processes in determining the amount of flexion or extension. It is useless to attempt to diagnose rotation or side-bending lesions by means of the spinous processes. In the first place, on account of the great variation in the points of the spinous processes, they present a very irregular line posteriorly. A long point on one side and a short point opposite might lead the operator to believe that rotation had occurred. Consequently, the spinous processes must be eliminated in diagnosis of rotation and side-bending movements. It is useless also to attempt to use the transverse processes. Examining their position, we find them to be anteriorly located, short and irregular, and so deeply placed in the neck that, unless the patient be very thin, the pressure required to locate them would be likely to cause considerable discomfort to the patient. Then, in the movements we wish to define, the transverse processes do not present sufficient variation in their position to warrant their use. We note that the articular processes in the cervical region are quite prominent, are regular in form, and are easily palpated. Even in the movements of flexion and extension, it is well to confirm the diagnosis by palpation of the articular processes. In flexion, they are separated; in extension, approximated. As described above, in lateral flexion and rotation, a combination of the two will be found, viz., the articular processes will be approximated on the side to which the face is turned, and separated on the opposite side. Also, it will be noted that, when two articular processes are found to be approximated, the upper will be

slightly more prominent, and when separated, the upper will be less prominent, showing the rotation of the vertebra together with lateral flexion. In the laboratory, we find very few variations of the articular processes. Should these occur, careful palpation, putting the region through all normal movements, will determine whether or not the bony prominence is a variation or indicative of a lesion.

Structures Affected

Bone.—Aside from the usual variations found in the bone in the cervical region, the most common abnormality is exostosis. This condition is found associated with all the articulations, and with each of the two kinds. It is not uncommon to find, in the laboratory, an overgrowth of either margin of the body of a vertebra. Unless this is marked, it does not interfere with movement, but, in most cases found, it is of sufficient size to limit some of the movement, or as in some cases, to form a bridge of bone from the body of one vertebra to the one adjacent. In some cases, this growth seems to have

Fig. 13. Superior surface of third cervical vertebra showing exostosis of right articular process and anterior portion of lower margin of body.

occurred as the result of an attempt on Nature's part to limit a movement that was too free; in other cases, it is found to be associated with a similar growth on the margins of the articular facets, and,

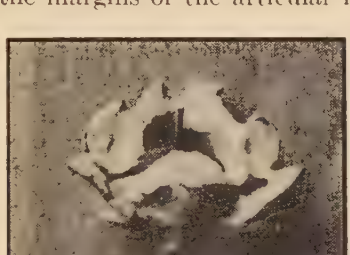


Fig. 14. Inferior surface of axis showing variation in inferior articular facets due to lesion.

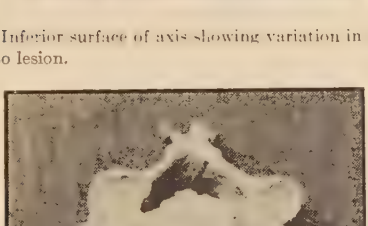


Fig. 15. Inferior surface of fourth cervical showing effect of lesion on the inferior articular facets.

in such cases, is the result of the lesion, causing pressure at some particular point, this pressure resulting in the overgrowth of bone. Several cases have been noted where the bridge of bone between two vertebrae was a complete union, and total loss of motion was the result. X-ray examination of any sus-

pected cases would confirm the diagnosis. On account of the very small body of the 3rd cervical vertebra, this condition is most commonly found between it and the 4th. Exostotic growths on the margin of the articular facets is always associated with lesions. These marginal growths are associated with extension lesions, being the result of increased pressure between the facets. This growth is most commonly found at the lower margin of the inferior articular facets, and in such cases there is a

Fig. 16. Ankylosis of third and fourth cervical vertebrae. A common abnormality.

compensatory hollowing out of the bone, posterior to the inferior margin of the superior articular facet below. It is interesting to note, if this condition is found to be marked on one side, that on the opposite side above or below, or both, a similar condition will be found, denoting an attempt to compensate for the primary lesion. Exostotic growths on the articular facets may be palpated, and this possibility should be taken into consideration in examination of the cervical region, as these growths may lead one to diagnose such a condition as a rotation and lateral flexion lesion, or possibly, in some cases,

where the growth is the same on each side, being symmetrically developed, it will simulate an extended condition. Ankylosis is most common between the 3rd and 4th cervicals and, when it occurs, seems to be preceded by exostosis of the articular facets and margins of the bodies. Careful examination for bony growths should be made, following the finding of any loss of normal movement. On account of the anterior portion of the cervical transverse process being in reality a costal process, we

Fig. 17. Ankylosis of the axis and third cervical.

occasionally note an elongation and separation of the costal process of the 7th cervical, forming a cervical rib. Considerable variation has been noted in this growth. In many cases, the costal process is merely elongated and not separated, to form a movable articulation. In other cases, the process may be separated and a complete synovial cavity formed, similar to the articulations of the ribs at the head and at the transverse process. In the latter case, none have been found that exceed one inch in length, and when present, do not normally give the patient any discomfort.

It must be kept in mind in the examination of the cervical vertebrae that there may be a number of variations of the spinous processes, especially those that are commonly bifid.

Ligaments.—Ligaments may become lax and thin. They may also be thickened, and are often found so, following sprain or rupture which, in the course of repair, will contract due to the formation of scar tissue. The latter condition seems to precede the formation of exostotic growths. In the cervical region, those most commonly affected are the capsular ligaments of the lateral articulations, and next the ligamentum nuchae. It is undoubtedly true that, if an articulation be forced beyond its normal range of movement, the tension thus produced will have to be borne by either the bony structure or the attached ligaments. In the movements of the cervical region, the ligaments play an important part in limiting movement and, consequently, will suffer, if this movement is carried beyond a certain point. In either form of motion, the capsular ligament is made tense at the extreme point of motion and would consequently be the first to be injured. The ligamentum nuchae will be injured more commonly in flexion or in cases of direct trauma. Thickened ligaments restrict movement. If restricted movement is unilateral, the result is lateral flexion and rotation, and if bilateral, it causes extension. Thin, lax ligaments allow hypermobility in all forms of movement.

Muscles.—On account of the great amount of movement of the cervical region, a large number of muscles are required, and with a great variation in

attachment. Inasmuch as a complete description of the origin and insertion of a muscle can be found in any standard anatomy, we will mention here only the name and its function with regard to the cervical region. Muscles may be the cause of lesions, and lesions may and do often result in the contracture of muscles. These two facts must be considered when contractured muscles are found. The principal muscles, moving the cervical region, and their function, will be found in the following list:

TRAPEZIUS, UPPER FIBERS.—Rotation and side-bending to same side, with face turned to opposite side. Extension, when both act.

LEVATOR ANGULAE SCAPULAE.—Rotation, side-bending and face to same side; extension, when both act.

SPLENIUS CERVICIS ET CAPITIS.—Rotation, side-bending and face turned to same side; extension, when both act.

ILIO-COSTALIS CERVICIS.—Rotation, side-bending of lower cervical to same side; extension, when both act.

LONGISSIMUS CERVICIS AND CAPITIS.—Rotation, side-bending and face turned to same side; extension, when both act.

SPINALIS CERVICIS AND CAPITIS.—Extension.

SEMI-SPINALIS CERVICIS.—Extension, with rotation, and side-bending to opposite side; both acting extend the cervical region.

SEMI-SPINALIS CAPITIS.—Extension with slight side-bending and rotation to same side; extension, when both act.

MULTIFIDUS.—Extension with side-bending and rotation to opposite side; both acting extend the cervical region.

INTERSPINALIS.—Extension.

INTERTRANSVERSARII.—Rotation and side-bending to same side. Both acting fix the neck, making it rigid. Especially well developed in the cervical region.

SCALENUS ANTICUS, MEDIUS AND POSTICUS.—Side-bending to same side, rotation to opposite side; rigidity with slight; flexion, if both act.

LONGUS COLLI.—Flexion with slight rotation and side-bending to same side.

RECTUS CAPITIS ANTICUS MAJOR AND MINOR.—Flexion with slight rotation and side-bending to same side.

STERNO-MASTOID.—Flexion with side-bending to same side, rotation to opposite side; both acting, flexion alone.

The infrahyoid and suprahyoid muscles will produce flexion, if their attachment to the hyoid bone be fixed.

Arteries.—The vertebral artery is the only one in direct relation to the cervical vertebrae. It may be injured or its wall torn in dislocation. In all normal movements, it follows the movement of the vertebra above and is sufficiently lax to allow for the normal movement without injury. Its nerve plexus follows it through the foramina in the transverse processes and may be subject to irritation, if a lesion is present, thus causing either increase or decrease in the amount of blood carried to the brain. The branches most often affected

are those passing through the intervertebral foramina to supply the spinal cord. These may be subjected to pressure, if lesions are present, especially those occurring in extension or side-bending rotation, on the side of the concavity.

The Intervertebral Foramina.—Laboratory experiments have brought out some very important facts regarding the movements of the cervical region and corresponding changes in the size of the intervertebral foramina. In the position of flexion, the foramina were found to be largest; in a position of extension, smallest, the difference in size being a decrease of 35%. This also occurred in

FIG. 18. (a) Actual size of a typical cervical intervertebral foramen in flexion. (b) Same foramen in extension.

the rotation and side-bending movement. On the side of the concavity of the curve, or on the side where the articular facets were approximated, the foramina were smallest, being the same as in extension. On the opposite side, or on the side where the articular facets were found to be separated, the foramina were the same as in flexion. This leads to the conclusion that extension lesions are more likely to cause pressure on the nerve, artery and vein, passing throuth the foramen than flexion lesions, and that, in rotation and side-bending lesions, the structures on the side of the concavity are most likely to suffer.

Viscera.—The only viscus in relation to the cervical vertebrae is the pharynx. It is not often that lesions are of sufficient extent to be diagnosed through the pharyngeal wall. Only in cases of caries or exostotic growths of the anterior surface of the bodies of the vertebrae, will it be noted as having any direct influence on the pharynx.

Nerves.—The typical cervical region is associated with the greater part of the origin of the cervical and brachial plexuses, the third to eighth

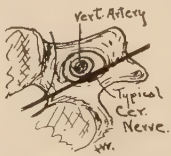


FIG. 19. Showing the relation of a typical cervical nerve to the upper surface of its corresponding vertebra.

spinal nerves leaving the spinal canal through the intervertebral foramina formed below the axis down to the one formed by the 7th cervical and 1st dorsal. In noting the position of the cervical nerves named for their respective vertebrae, it must be remembered that the 3rd cervical nerve leaves the canal between the 2nd and 3rd vertebrae. This relation persists until we find the 8th cervical nerve leaving the canal below the 7th cervical vertebra. This rule applies to the relation of the cervical nerves to their respective vertebrae. In the cervical region, the nerve named for the vertebra leaves the spinal canal ABOVE its vertebra, except the last or 8th. There being no 8th cervical vertebra, it leaves the spinal canal below the 7th cervical ver-

tebra. This applies to the cervical region only, as we find that in the other regions the nerve will leave the spinal canal BELOW the vertebra for which it is named.

It will be more convenient to take each cervical segment and briefly state the various impulses associated with it and the structures possibly affected. No reference will be made to the anterior or posterior primary division, as either or both may be affected by a lesion, inasmuch as they are merely divisions of the nerve that makes its exit from the spinal canal.

Third Cervical Segment

VOLUNTARY.—Trapezius, sterno-mastoid, infra-hyoid group, scaleni, anterior recti, longus colli, diaphragm, levator angulae scapulae, splenius cervicis et capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis and capitis, semispinalis cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii.

INVOLUNTARY.—Connected with the superior cervical ganglion of the lateral chain, receiving impulses that are carried over the cutaneous nerves to the skin. The transverse process is in relation to this ganglion and lesions may result in a disturbance of it, interfering with involuntary impulses, carried to the head, and to the neck region.

SENSORY.—Back and side of head; angle of mandible, neck, shoulder and upper part of thorax, anteriorly.

ARTICULAR.—Spinal articulations; sterno-clavicular and acromio-clavicular articulations.

Fourth Cervical Segment

VOLUNTARY.—Trapezius, sterno-mastoid, scaleni, rectus capitis anticus major, longus colli, diaphragm, levator angulae scapulae, splenous cervicis et capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis and capitis, semispinalis cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii.

INVOLUNTARY.—Connected with the superior cervical ganglion of the lateral chain, receiving impulses that are carried over the cutaneous nerves to the skin. The superior cervical ganglion lies above this segment, but may be affected by it, due to the connecting fibers between the various ganglia of the chain.

SENSORY.—Posterior and postero-lateral portion of neck, shoulder, and upper anterior portion of thorax.

ARTICULAR.—Spinal, sterno-clavicular and acromio-clavicular.

Fifth Cervical Segment

VOLUNTARY.—Scaleni, rectus capitis anticus major, longus colli, diaphragm, splenius cervicis et capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis and capitis, semispinalis cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii, rhomboideus major and minor, subclavius, supraspinatus, infraspinatus, pectoralis major, serratus magnus, deltoid, teres major and minor, subscapularis, lattissimus dorsi, and the muscles of the upper extremity, controlled

by musculo-spiral, musculo-cutaneous, and median nerves.

INVOLUNTARY.—Connected with the middle cervical ganglion of the lateral chain, receiving impulses that are carried over the cutaneous nerves to the skin. The middle ganglion lies below the transverse process of the 5th cervical vertebra and may be subject to irritation when lesions of the 5th occur.

SENSORY.—Postero-lateral surface of arm, radial side of forearm and hand.

ARTICULAR.—Spinal, shoulder, elbow, wrist, and articulations distal to wrist on radial side.

Sixth Cervical Segment

VOLUNTARY.—Scaleni, longus colli, splenius cervicis and capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis and capitis, semispinalis cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii, subclavius, supraspinatus, infraspinatus, pectoralis major, serratus magnus, deltoid, teres major and minor, subscapularis, latissimus dorsi, and the muscles of the upper extremity, supplied by musculo-spiral, musculo-cutaneous, and median nerves.

INVOLUNTARY.—Connected with the middle cervical ganglion of the lateral chain, carrying impulses distributed over the cutaneous nerves, associated with the segment. The middle cervical ganglion lies above the transverse process of the 6th cervical vertebra and may be subject to irritation, when lesions of the 6th occur.

Sensory.—Postero-lateral surface of arm, radial side of forearm and hand.

Articular.—Spinal, shoulder, elbow, wrist, and articulations distal to wrist on radial side.

Seventh Cervical Segment

Voluntary.—Longus colli, splenius cervicis et capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis and capitis, semispinalis cervicis and capitis, rotatores, multifidus, intertransversarii, interspinales, pectoralis major, serratus magnus, deltoid, teres major and minor, subscapularis, latissimus dorsi, and the muscles of the upper extremity, supplied by the musculo-cutaneous, musculo-spiral and median nerves.

Involuntary.—Connected with the inferior cervical ganglion of the lateral chain, receiving impulses that are carried over the cutaneous nerves, originating from this segment. This ganglion is found between the transverse process of the 7th cervical and that of the 1st dorsal and is subject to irritation, when lesions of the 7th cervical vertebra occur.

Sensory.—Postero-lateral surface of arm, radial side of forearm and hand.

Articular.—Spinal, shoulder, elbow, wrist, and articulations distal to wrist on radial side.

Eighth Cervical Segment

Voluntary.—Splenius cervicis and capitis, ilio-costalis cervicis, longissimus cervicis and capitis, spinalis cervicis, semispinalis cervicis and capitis, multifidus, rotatores, intertransversarii, inter-

spinales, pectoralis major and minor, subscapularis, teres major and minor, deltoid, latissimus dorsi, and the muscles of the upper extremity, supplied by the musculo-spiral median, and ulnar nerves.

INVOLUNTARY.—Connected with the inferior cervical ganglion of the lateral chain, receiving impulses that are carried over the cutaneous nerves, originating from this segment.

SENSORY.—Arm, ulnar side of forearm, palm and dorsal surface on radial side of hand.

ARTICULAR.—Shoulder, elbow, wrist, and articulations distal to wrist on ulnar side.

Movement.—Normally the lower cervical segments, making up the typical cervical articulations, are freely movable in the various planes as described above. Flexion and extension are free. In palpation, special attention should be given to this movement, as rotation and side-bending lesions will limit flexion or extension and vice versa. Any limitation of movement should be considered a lesion, also hypermobility indicates an abnormality of the articulation. Movement is always controlled by muscles. Consequently, any variation from the normal indicates not only a thoro examination of the bony structure, but also any musculature that may pass over the articulation. Lipoma, goiter or other growths of the cervical region tend to limit movement and by their weight or position may be the primary cause of loss of motion. Variation must be allowed for, such as difference in length of cervical region and fatty deposit or obesity.

CHAPTER IV.

THE DORSAL REGION

The general characteristics of the dorsal vertebrae are the same as those of the cervical region. But in this region we find a variation in function and movement, and it is well to note the anatomical variations or points of difference from other regions, in order to appreciate their effect.

In general, the bodies of the dorsal vertebrae are heart-shaped. This does not apply to the first two nor the last one, as they represent an intermediate form with the adjacent regions. On account of the dorsal curve being concave anteriorly, the body of the vertebra will be slightly thinner anteriorly than posteriorly, showing that the curve

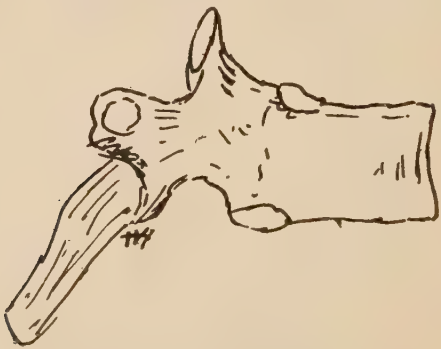


FIG. 20. Typical dorsal vertebra, side view.

FIG. 21. Typical dorsal vertebra, superior surface.

is not due altogether to the variation in the thickness of the intervertebral discs.

The pedicles are attached to the upper border of the body and are directed posteriorly, but slightly outward and upward. This arrangement causes the intervertebral foramen to be formed by a greater part of the vertebra above than the one below.

The superior articular processes are situated slightly anterior to the plane of the inferior and are found at the junction of the pedicles with the transverse process. Their plane of articulation is directed backward with slight upward and outward inclination. The inferior articular processes are found at the junction of the transverse process with the lamina and are deeply placed, being in a plane anterior to that of the tip of the transverse process. The articular surface is directed forward, slightly inward and downward.

The transverse processes are strong rounded masses directed backward, outward and slightly upward, and, with the exception of the last two, present at the tip an articular surface for the corresponding rib.

The laminae are arranged in a slanting manner so that they overlap, the succeeding vertebra thus forming, in this region, an almost complete bony covering for the spinal canal.

The spinous process is long and slender, and directed downwards, ending in a slightly marked tubercle or enlargement. This obliquity is most marked at the spine of the 7th dorsal, gradually becoming less as the lumbar region is approached.

The characteristic feature of the dorsal region is the series of articular facets for the ribs on the bodies of the vertebrae and at the tip of the transverse processes. This feature makes some of the dorsal vertebrae peculiar and, at the same time, varies the possibility of rib lesions associated with lesions of the dorsal vertebrae. This point should be kept in mind and will later be discussed in the chapter on the ribs.

Altogether, including the articulations of the ribs, there are one hundred articulations associated with the dorsal vertebrae. Of these thirty-six are typical, that is, between the vertebrae themselves, and are similar to the typical articulations in the cervical region. Each dorsal vertebra articulates with its fellow below by means of the intervertebral disc and by the two lateral series of articular processes. The ligaments, binding these articulations together, are the same in name and function as are

found in the typical cervical region and do not need further consideration. The remaining sixty-four articulations are with the ribs and will be considered under that subject.

Movements

Flexion and Extension.

Lateral Flexion and Rotation combined.

Before describing the movement in the dorsal region, it is well to give some thought to the ne-

Fig. 22. Dr. Halladay demonstrating flexion of the spine. Note the obliteration of the cervical curve, increase in the dorsal and obliteration of the lumbar curve.

cessity for free or restricted motion in this particular region. One of the main functions of the dorsal vertebrae is for the support of the ribs, which in turn are for the purpose of protecting the enclosed viscera. In the normal performance of their function, the ribs must be freely movable and must have a fixed point upon which to move. The attachment of the ribs to the dorsal vertebrae makes it desirable that the vertebrae be fixed more or less during movements of the ribs. Hypermobility of the dorsal vertebrae would cause, through the ribs, increased pressure, displacement, or deformity of the structures, normally to be protected by the bony cage. Thus we find, on account of the peculiar function of this region, that some movements are restricted, others free.

Flexion in the dorsal region is limited. In this movement, there is an increase in the normal curve which is concave anteriorly. It is to be noted that the movement is not evenly distributed; but that the greater part occurs in the lower dorsal region. This is explained, when we note the attachment of the true ribs and take into consideration the effect of too free motion in this direction upon the thoracic viscera beneath. In this movement, we see practically the same relations between the dorsal vertebrae as was noted between the cervical in the same movement, but limited. The spinous processes will be separated and in this position more easily palpated. The laminae are separated, the lower border of one, being in nearly the same plane as the upper border of the one below. The ligamenta flava are stretched and, in this region, are the

FIG. 23. Dr. Halladay demonstrating extension. Compare with figure 22 and note the changes in the spinal curves.

main structures to prevent too great forward-bending, being narrow and quite thick. The inferior articular facets have moved upward and forward upon the superior articular facets of the vertebra below. There will be separation of the transverse processes, but not to the same extent as of the spinous processes. There will be compression of the intervertebral disc anteriorly with relaxation of the anterior common ligament. All of the above facts are noted to exist to a greater degree in the lower

dorsal region. In this movement, there should not be normally any degree of rotation.

Extension is also a limited movement and occurs more in the lower dorsal than in the upper part of the region. It is possible to entirely obliterate the dorsal curve by this motion and it is first noted to disappear in the lower part of the region. Extension is limited by the approximation of the laminae and spinous processes and intervening ligaments, and by the tension on the anterior common ligaments. In this position, the spinous processes are approximated and their tips so closely related, that differentiation is often difficult. This is especially true of the lower dorsal spinous processes that are approaching the lumbar ones in form. The inferior articular facets have moved downwards and backwards upon the superior articular facets of the vertebra below, and the articular capsule is tense over their inferior margin. The transverse processes are approximated, their tips being in practically a straight line from the first to the twelfth. There is compression of the disc posteriorly and stretching of it anteriorly, with marked tension on the anterior common ligament. This movement in the dorsal region will vary in the individual, depending upon the age, it being in the young about 90 degrees and gradually reducing to the practically fixed curve of old age. This change is due to the loss of elasticity in the intervertebral disc, rather than to any pathological changes in the form of the vertebrae or ligaments.

Rotation and lateral flexion are combined. Either of these movements may be the initiatory

movement, but the other must follow to a greater or less degree. As in the cervical region, this movement is in reality a combination of flexion and extension, but, on account of being a much freer movement comparatively, shows certain variations from the typical cervical rotation and lateral flexion. If the greater amount of force be used in a rotary motion, we see a gliding of the facets in a nearly horizontal plane, but with a slight upward and forward motion on one side, accompanied by a cor-

Fig. 24. Dr Halladay demonstrating a dorsal curve. Note the position of the ribs and spinous processes on each side.

responding amount of downward and backward movement on the opposite side. This produces a concavity and convexity laterally with a twist or rotary movement, the spine being turned to the convexity of the curve and the body turned slightly to the concavity. Noting the position of the transverse processes, those on the side of the convexity are separated, and the one above is in a plane anterior to the one below. On the concavity, the transverse processes approach a straight line, being more nearly in the same plane, yet the one above being found slightly in advance of the one below. If the greater amount of force be applied in producing a side-bending, it will be noted first that there is a great increase in the lateral concavity and convexity and that the rotation, while present, is not of as great a degree as is possible. This lateral movement more nearly simulates flexion on the side of the convexity and extension on the side of the concavity, the articular facets being in the same position as cited above in the description of that motion. There is some rotation, so the analogy is not exact, as we find that on the side of the concavity the inferior articular facets have moved downward, backward and slightly inward, while on the side of the convexity the inferior articular facets have moved upward, forward and slightly outward. The spinous process is found to the side of the convexity. It is also shown in the laboratory, that, if the spine be rotated to its extreme point of movement, there may still be some side-bending which will allow of a small increase in the rotation already present. Also at the extreme point

of the side-bending movement, the spine may be rotated and thus allow a slight increase in the (already present) side-bending. As is the case with flexion and extension, the movements of rotation and side-bending are less in some parts of the dorsal region than in others. Rotation is most marked in the upper dorsal and diminishes until it is not present except to a small degree at the dorso-lumbar articulation. Side-bending is limited in the upper dorsal and becomes more free as the lumbar region is approached. Each movement is limited more in extension than in flexion, in fact, hyper-extension prevents rotation and side-bending, while extreme flexion limits either movement only to a very small degree. As with the cervical region, anterior or posterior movement in the plane of the intervertebral disc is impossible without fracture of some of the bony parts of the vertebrae involved. Thus the terms "anterior," or "posterior dorsal" are misnomers and should not be used.

Diagnosis

In palpating for movement in the dorsal region, it must be kept in mind that the movements of flexion and extension are not as free as in the cervical region, but that rotation and lateral flexion are free and may be called the characteristic movements of this region. We must, then, choose bony prominences that will indicate these movements with accuracy. A bony prominence that can under all conditions be palpated is the spinous process. This, however, is subject to many variations, some of which are very misleading and apparently indicate lesions when none occur. This is especially true, when spinous processes are found

bent to one side or the other, giving the appearance of rotation and lateral flexion lesions. In the erect position or a position of rest, all the dorsal spinous processes may be palpated. These should be found in the median furrow of the back and in line with a perpendicular dropped from the external occipital protuberance. Any deviation from this line indicates an abnormality, either in the form of a lesion or showing the presence of a lateral curve of the spine. Regardless of the variation in the growth of the spinous processes, they may be used to advantage in palpating for movement. In flexion the spinous processes are separated in the midline, there

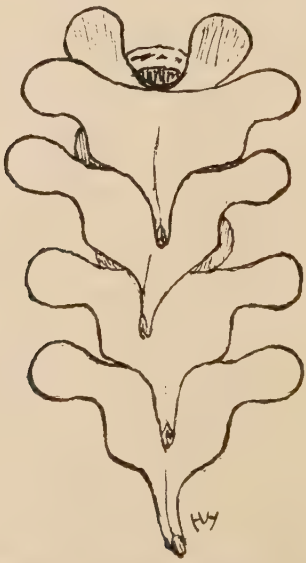


FIG. 25. Variations in spinous processs not indicating lesions. Taken from laboratory findings showing that the bent spinous processes were due to variation in muscular development.

being normally no turning to one side or the other. In this movement, as in extension, we note a symmetrical movement of the articular facets. In case there is limitation of movement on one side, there may be lateral movement of the spinous process, and in such cases in flexion, the spinous process is turned slightly to the side opposite the point of impaired movement. In extension, the spinous processes are approximated and are less easily palpated. In this movement, if the articulations are normal, there will be no turning to one side or the other, but, in case the facets do not move the same on each side, the spinous process will be turned to the side of the lesion or lost motion. In flexion, the spinous processes are prominent and easily palpated and, when flexion occurs between two vertebrae, the spine of the upper one will be the more prominent. This gives rise to the statement that a vertebra may be posterior. As discussed in connection with the cervical region, this condition, or that of "anterior dorsal", is impossible. A spinous process easily palpated and separated from its fellow below indicates flexion; if it is difficult to palpate and approximated to the one below, it indicates extension. On account of the comparatively small amount of flexion and extension, it is difficult to determine either of these movements by palpating the transverse processes. There is movement between them, as we find slight separation in flexion and approximation in extension. The articular processes in the dorsal region are deeply placed and covered by dense muscle fibers to such an extent that it is not practical to attempt to use

them. We should, however, visualize their movements, as the spine is put through its movements. The spinous processes in the dorsal region are, then, the best guide to the movements of flexion and extension.

In the description of the rotation and side-bending movement, we have already noted the position of the vertebrae and their parts. In the diagnosis of this movement which is so important, we should note which of these bony prominences can be best used. On account of the freedom of this movement and the variation in position of the transverse processes, they can be used as well as the spinous processes in determining the extent of the lesion. With the exception of the first and second, the transverse processes can be easily palpated. They will be found about one inch to the side of the line of spinous processes and between the longitudinal fibers of the longissimus and the spinalis muscles. In the rotation-side-bending movement, the position of both transverse processes and the spinous process of the vertebra must be noted. In rotation to the right, the left transverse process will be difficult to palpate, having passed upward and forward, the spinous processes will be turned to the left, and the right transverse process will be easily palpated, and, at a slightly lower level than its fellow, having passed downward and backward. Many mistakes are made because the operator does not know the normal relation between the spinous processes and their respective transverse processes. This is difficult to remember on account of the great obliquity of certain dorsal spin-

ous processes, while others are more nearly straight. The following data as to this relation were derived from the several special specimens, prepared in the laboratory:

The spinous process of the seventh cervical vertebra is in the same horizontal plane with the articulation between the seventh cervical and the first dorsal vertebrae and the first dorsal transverse process.

The spinous process of the first dorsal is in the same plane as the articulation between the first and second dorsal and the transverse process of the second dorsal.

The spinous process of the second dorsal is in the same plane as the articulation between the second and third dorsal and the transverse process of the third dorsal.

The spinous process of the third dorsal is in the same plane as the articulation between the third and fourth dorsal and the transverse process of the fourth dorsal.

The spinous process of the fourth dorsal lies in a plane passing between the articulations of the fifth dorsal vertebra and between the transverse processes of the fifth and sixth dorsal.

The spinous process of the fifth dorsal is in the same plane as the articulation between the sixth and seventh dorsal and between the transverse processes of the sixth and seventh dorsal.

The spinous process of the sixth dorsal is the in the same plane as the articulation between the seventh and eighth dorsal and the transverse process of the eighth dorsal.

The spinous process of the seventh dorsal is in the same plane as the articulation between the eighth and ninth dorsal and between the transverse processes of the eighth and ninth dorsal.

The spinous process of the eighth dorsal lies in a plane passing between the articulations of the ninth dorsal and between the transverse processes of the ninth and tenth dorsal.

The spinous process of the ninth dorsal is in the same plane as the articulation between the ninth and tenth dorsal and the transverse process of the tenth dorsal.

The spinous process of the tenth dorsal is in the same plane as the articulation between the tenth and eleventh dorsal and the transverse process of the eleventh dorsal.

The spinous process of the eleventh dorsal lies in a plane passing between the articulations of the eleventh dorsal, but through the transverse process of the twelfth dorsal.

The spinous process of the twelfth dorsal is in the same plane as the articulation between the twelfth dorsal and the first lumbar and the transverse process of the first lumbar.

The ribs also have a diagnostic value in determining movement in the dorsal region. This feature will be taken up with the discussion of the costal movements and articulations.

Structures Affected

Bone.—More abnormalities of the dorsal vertebrae than of the cervical are found. This is due to the great increase in weight that must be borne by this region. The part of the vertebrae affected and the extent of the condition will depend, as may

be supposed, upon the cause. The body of the vertebra being constructed of cancellous bone is often affected and may be the only part to suffer to any great extent. In scoliosis, we see the wedge-shaped body, the apex of the wedge being found either in an antero-lateral, lateral or postero-lateral position. The body is affected in Pott's disease, it being entirely destroyed, the result of which is the prominent angle noted posteriorly in the spine. Necrosis of the body follows aneurism of the descending thoracic aorta and may be so extensive as to completely destroy the body, so that the aneurysm presses upon the spinal cord. Laboratory findings in such cases show the intervertebral disc to be practically normal. Exostosis is common and often is found bridging over the intervertebral disc, resulting in ankylosis of two adjacent vertebrae. The transverse processes are rarely affected except in cases of fracture and, on account of their exposed

FIG. 26. Laboratory specimen showing the effect of Pott's disease The body of the vertebra is compressed forming a thin wedge the apex of which is anterior.

position, may be the only parts to suffer in such cases. The articular processes show the effect of lesions readily. Normally the articular processes of each vertebra should be symmetrical. Asymmetry is common and is associated with variations in the transference in weight from above. On one side, we may find a normal articular process and, on the other side, one showing the effect of increased weight in the form of a larger articular surface and mar-

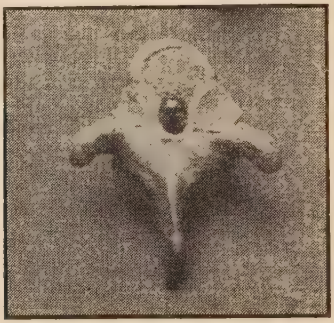


Fig. 27. Superior surface of fifth dorsal showing the effect of lesion on the articular facets.

ginal exostotic growths. Ankylosis may begin in the articular processes and is commonly found in the upper dorsal region in the aged. Articular processes, affected on one side only, show in the laboratory compensation above and below, in the form of abnormalities on the opposite side. The laminae are rarely affected except in fracture involving the spinous process. Complete ankylosis involves all adjacent surfaces and margins of the vertebrae affected and will in such cases include the laminae.

The spinous process is subject to many variations, being principally the result of variation in the strength of attached muscles. Thus we find bent spinous processes, the deviation being to the right or left, or there may be a variation in the obliquity. The spinous process may be fractured and, in the healing, may not join at the base resulting in a movable spinous process. A congenital deformity occasionally met with is spina bifida which is found in varying degrees.

Foramen.—The intervertebral foramina vary with the position of the vertebrae. In flexion, the

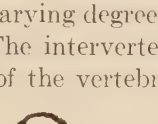


Fig. 28. Actual size of dorsal intervertebral foramen in flexion and extension, the larger representing flexion.

foramen is larger and in extension, smaller. This variation in size is not so marked as during the movements of rotation and side-bending. In rotation and side-bending, on the side of the convexity the foramen is enlarged, and on the side of the concavity it is much smaller, there being a difference of about thirty-five per cent in the area. It will be noted, then, that in extension and on the side of the concavity, there is a greater chance for interference with the intervertebral structures.

Ligaments.—The ligaments in the dorsal region are similar to those in the cervical region. The ones most commonly affected are the capsular. These, as in other regions, are subject to strain at the point of normal limitation of movement and

show the effect of this in a thickening and contracture which results in impaired movement. Injury to any ligament will result in its contracture and this is the common cause of lesions. In old age, the supra-spinous ligament and ligamenta flava may partly ossify. This is especially true in cases where exostotic growths are found or where other findings indicate injury or lesions.

Muscles.—The muscles affecting movements in the dorsal region are many and their attachments complicated. A large number of them act on the dorsal region as a whole and not particularly on the spinous process. These are attached to the ribs and thus aid in the production of the movements. The action only will be given in the following list:

Ilio costalis lumborum and dorsi.—Rotation and side-bending to the same side; both acting will result in extension.

Longissimus dorsi and cervicis.—Rotation and side-bending to the same side; both acting will result in extension.

Spinalis dorsi and cervicis.—Extension.

Semispinalis dorsi and cervicis.—Rotation and side-bending to the opposite side; both acting result in extension.

Multifidus.—Rotation and side-bending to the opposite side; both acting result in extension.

Rotatores.—Rotation and side-bending to the opposite side; both acting result in extension.

Interspinales.—Extension.

Intertransversarii.—Rotation and side-bending to same side; both contracting result in fixation of the spine.

Rectus abdominis.—Flexion.

External oblique.—Rotation and side-bending to the opposite side; both contracting result in flexion.

Internal oblique.—Rotation and side-bending to the same side; both acting result in flexion.

Transversalis.—Rotation and side-bending to the opposite side.

Pectoralis major and minor.—Each acting on both sides produces extension.

Sterno-mastoid.—Assists in extension.

Arteries.—The only arteries that may be directly affected by dorsal lesions are the branches that pass through the intervertebral foramina to supply the spinal cord. These are accompanied by the corresponding vein and nerve and are subject to pressure on the side of the concavity in rotation, side-bending and hyperextension, the foramina being greatly reduced in size in these positions. Indirectly, other arteries are affected by group lesions or scoliosis and in other kinds of deformity of the thoracic region. The nerve supply of all of the arteries of the body is derived from the thoracolumbar division of the involuntary nervous system, and dilatation or constriction of any series of arteries may occur, following irritation to the dorsal nerves nerves.

Viscera.—The relation of the oesophagus to the bodies of the dorsal vertebrae is important, as, in cases of Pott's disease or any condition resulting in thoracic deformity, there will be a deviation of the oesophagus from its normal position. This may result in either atresia or difficulty in swal-

lowing. Indirectly, the heart or lungs may be affected due to the pressure of the ribs, their abnormal position being due to structural changes in the dorsal vertebrae. This also applies to the viscera of the abdomen related to the ribs, as the liver, stomach, spleen and kidneys.

Nerves.—As far as the formation of plexuses is concerned, the dorsal nerves, with the exception of the first and last, play no part. It is in this region that we find the typical arrangement of a spinal nerve, and as far as the distribution of voluntary and sensory impulses is concerned, the arrangement is very simple. The truly important feature of the dorsal nerves is that, with the exception of the first, they carry from the spinal cord most of the impulses over fibers connecting with the thoraco-lumbar cord of the involuntary nervous system, and it is for this reason that dorsal lesions and abnormalities are responsible for pathology at some distant point. It is not sufficient that the reader stop with the following tabulation of the dorsal nerves, but he should make a careful study of the chapter given later on the Involuntary Nervous System. As with the cervical region, no attempt will be made to differentiate between the anterior and posterior primary divisions. The text is confined to the various impulses carried by the particular segment, and not by any specially named branches.

First Dorsal Segment

VOLUNTARY.—Serratus posticus superior, splenius cervicis and capitis, erector spinae mass, semispinalis dorsi, cervicis and capitis, multifidus, rota-

tores, interspinales, intertransversarii, levatores costarum, intercostals, and pectoralis major and minor, also muscles of the upper extremity, supplied by the musculo-spiral, median and ulnar nerves.

INVOLUNTARY.—Connected with the stellate or first dorsal ganglion of the lateral chain by a grey ramus which carries impulses to the cutaneous nerves, originating from this segment.

SENSORY.—Arm, ulnar side of forearm, palm of hand, dorsal surface on the radial side of hand, the skin of the back, corresponding to the area related to the spinous process of the first dorsal.

ARTICULAR.—Articulations of the upper extremity, and corresponding spinal and costal joints.

Second Dorsal Segment

VOLUNTARY.—Serratus posticus superior, splenius cervicis and capitis, erector spinae mass, semispinalis dorsi, cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals and triangularis sterni.

INVOLUNTARY.—Connected with the second dorsal ganglion of the lateral chain by a grey ramus which carries impulses to the cutaneous nerves, originating from this segment; furnishes a white ramus that is part of the origin of the thoraco-lumbar cord of the involuntary nervous system and carries involuntary impulses to the upper half of the body.

SENSORY.—To the floor of the axilla, the skin and pleura corresponding to the second interspace, and the skin of the back in the region of the spinous process of the second dorsal.

ARTICULAR.—To the corresponding spinal and costal articulations.

Third Dorsal Segment

VOLUNTARY.—Serratus posticus superior, splenius cervicis and capitis, erector spinae mass, semispinalis dorsi, cervicis and capitis, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals and triangularis sterni.

INVOLUNTARY.—Connected with the third dorsal ganglion of the lateral chain by a grey ramus which carries involuntary impulses back to the spinal nerve; furnishes, as part of the origin of the thoraco-lumbar cord, a white ramus which carries involuntary impulses to be distributed to the upper half of the body.

SENSORY.—To the skin and pleura corresponding to the third interspace, and the skin of the back in the region of the spinous process of the third dorsal.

ARTICULAR.—To the corresponding spinal and costal articulations.

Fourth Dorsal Segment

VOLUNTARY.—Splenius cervicis and capitis, erector spinae mass, semispinalis dorsi and cervicis, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals, and triangularis sterni.

INVOLUNTARY.—Connected with the fourth dorsal ganglion of the lateral chain by a grey ramus which carries impulses to the fourth spinal, dorsal segment; furnishes a white ramus which passes to the lateral chain as part of the origin of the thoraco-

lumbar cord and carries involuntary impulses to the upper half of the body.

SENSORY.—To the skin and pleura, corresponding to the fourth interspace, and the skin of the back in the region of the fourth dorsal spinous process.

ARTICULAR.—To the corresponding spinal and costal articulations.

Fifth Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi and cervicis, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals and triangularis sterni.

INVOLUNTARY.—Connected with the fifth dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord. Impulses arising from this segment are partly distributed to the upper half of the body and partly to the lower half through the great splanchnic nerve.

SENSORY.—To the skin and pleura corresponding to the fifth interspace, and the skin of the back in the region of the fifth dorsal spinous process.

ARTICULAR.—To the corresponding spinal and costal articulations.

Sixth Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinalis, intertransversarii, levatores costarum, intercostals, triangularis sterni, external oblique, internal oblique, rectus abdominis.

INVOLUNTARY.—Connected with the sixth dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and transmits the impulses to the lower half of the body through the great splanchnic nerve.

SENSORY.—To the skin and pleura corresponding to the sixth interspace, and to the skin of the back in the region of the sixth dorsal spinous process. Sensory to the anterior part of the diaphragm and small area of the anterior abdominal wall beneath the ensiform cartilage.

ARTICULAR.—To the corresponding spinal and costal articulations.

Seventh Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals, external oblique, internal oblique, rectus abdominis.

INVOLUNTARY.—Connected with the seventh dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits the impulses to the lower half of the body through the great splanchnic nerve.

SENSORY.—To the skin and the pleura of the seventh interspace, and to the back in the region of the spinous process of the seventh dorsal; an-

teriorly, to the diaphragm and the anterior abdominal wall above the umbilicus.

ARTICULAR.—To the corresponding spinal and costal articulations.

Eighth Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, intercostals, external oblique, internal oblique, rectus abdominis.

INVOLUNTARY.—Connected with the eighth dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits the impulses to the lower half of the body through the great splanchnic nerve.

SENSORY.—To the skin and pleura of the eighth interspace, and to the skin of the back in the region of the eighth dorsal spinous process; anteriorly, to the diaphragm and anterior abdominal wall above the umbilicus.

ARTICULAR.—To the corresponding spinal and costal articulations.

Ninth Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, serratus posticus inferior, intercostals, external oblique, internal oblique, transversalis, and rectus abdominis.

INVOLUNTARY.—Connected with the ninth dorsal ganglion by a grey ramus which carries invol-

untary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits impulses to the lower half of the body thru the great splanchnic nerve.

Sensory.—To the skin and pleura corresponding to the ninth interspace, and to the skin of the back in the region of the ninth dorsal spinous process; anteriorly, to the diaphragm and the anterior abdominal wall above the umbilicus.

Articular.—To the corresponding spinal and costal articulations.

Tenth Dorsal Segment

Voluntary.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, serratus posticus inferior, intercostals, external oblique, internal oblique, transversalis, and rectus abdominis.

Involuntary.—Connected with the tenth dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits impulses to the lower half of the body through the lesser splanchnic nerve.

Sensory.—To the skin and pleura corresponding to the tenth interspace, and to the skin of the back in the region of the tenth dorsal spinous process; anteriorly, to the diaphragm and the anterior abdominal wall below the umbilicus.

Eleventh Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, levatores costarum, serratus posticus inferior, intercostals, external oblique, internal oblique, transversalis, rectus abdominis.

INVOLUNTARY.—Connected with the eleventh dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits impulses to the lower half of the body through the lesser splanchnic nerve.

SENSORY.—To the skin and pleura corresponding to the eleventh interspace, and to the back in the region of the eleventh dorsal spinous process; laterally, to the abdominal wall and diaphragm, and anteriorly, to the abdominal wall below the umbilicus.

ARTICULAR.—To the corresponding spinal and costal articulations.

Twelfth Dorsal Segment

VOLUNTARY.—Erector spinae, semispinalis dorsi, multifidus, rotatores, interspinales, intertransversarii, serratus posticus inferior, intercostals, external oblique, internal oblique, transversalis, rectus abdominis, pyramidalis, psoas magnus and parvus, and quadratus lumborum.

INVOLUNTARY.—Connected with the twelfth dorsal ganglion by a grey ramus which carries involuntary impulses back to the spinal nerve, to be

distributed over the various parts of the nerve; furnishes a white ramus which serves as part of the origin of the thoraco-lumbar cord and which transmits impulses to the lower half of the body through the least splanchnic nerve.

SENSORY.—To the skin of the back in the region of the twelfth dorsal spinous process; laterally, to the abdominal wall and over the crest of the ilium to the anterior gluteal region; anteriorly, above Poupart's ligament and symphysis pubis.

ARTICULAR.—To the corresponding spinal and costal articulations.

Movement.—After establishing the fact that there is movement at the various dorsal articulations, the next thing to determine is whether or not it is within the normal range. Every possible factor that may influence the growth and development of this region must be taken into consideration. It must be remembered that, in the normal movement, variation exists in the region itself as to the degree of flexion and extension or the amount of flexion and extension occurring with side-bending-rotation. The articulation between the twelfth dorsal and first lumbar vertebrae is a typical lumbar joint and must be remembered as such. Movement in the dorsal region is influenced by the ribs to a great extent and by pathology associated with any of the thoracic viscera.

CHAPTER V.

THE RIBS AND STERNUM

A discussion of the thoracic region would be incomplete without a description of the ribs and sternum. This is especially true, considering the object of this work, since abnormalities of the ribs and sternum may occur independently of the thoracic vertebrae, but are frequently associated with vertebral variations, on account of the intimate relations existing between them.

The ribs are arranged in twelve pairs, each

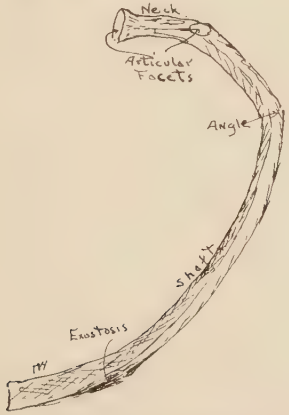


FIG. 29. Drawing from laboratory specimen of sixth rib. The exostosis present near the anterior extremity was due to fracture.

named for the dorsal vertebra with which it articulates. One from the central portion of the dorsal region may be taken for a typical description, but, on account of the normal variations found above and below, some of the ribs will require special mention. Also, on account of the difference in attachment anteriorly, the ribs are divided into three kinds: true, or those that are directly attached to the sternum anteriorly by means of their costal cartilages, which are seven in number; false, or those that are attached indirectly to the sternum, being attached to the rib above, and are three in number; and the last two, or floating ribs, having only the posterior articulation with the corresponding dorsal vertebrae.

A typical rib is a flat bone curved in almost semicircular form and twisted on its long axis. The head of the rib is found at the vertebral end and presents two facets for articulation with the lower border of the body of the vertebra above and the upper border of the body of the vertebra for which it is named. Between these articular facets is a ridge or interarticular crest which serves for the attachment of a ligament which binds the head of the adjacent intervertebral disc. The neck of the rib is a narrowed portion of the shaft, extending in the direction of the transverse process of the corresponding vertebra, and is smooth anteriorly, being covered by pleura, but rough posteriorly for the attachment of ligaments. The tubercle is posteriorly located and marks the junction of the neck with the shaft of the rib. It is an articular surface, forming the costo-transverse articulation between

Fig. 30. The prepared spine bent to show the approximation and separation of the ribs accompanying the movement.

each rib and the transverse process of its corresponding vertebra. The angle of the rib is found along the shaft and marks the point where the rib makes a sharp turn forward; it also represents the lateral border of the erector spinae mass. Anteriorly, the typical rib is continued to an attachment to the sternum by means of its costal cartilage, which will be seen to articulate with the rib, but without any

intervening synovial membrane. The sternal articulation of the costal cartilages forms a true diarthrodial joint, there being present a synovial membrane, this existing in connection with the eighth, ninth and tenth ribs where they join the costal cartilages of the rib above. The surfaces of the ribs may be more conveniently referred to as in-

FIG. 31. The superior surface of the first rib. Note that it is completely covered by structures.

ternal and external, and in each case the internal surface is found to be covered by pleura, while the external surface is related to the thoracic musculature. Each rib also has a superior and inferior border to which is attached the series of intercostal muscles.

The first rib, on account of variations, needs special attention. Its head, instead of being divided by two articular surfaces, is rounded and articulates

with the upper border of the body of the first dorsal vertebra only. It is the shortest of the ribs, placed in a horizontal plane, and is comparatively broader. It has a superior surface, serving for the attachment of muscles and over which the subclavian artery and vein and the greater part of the first dorsal nerve pass, to be found later in the axillary space. Its internal surface is covered by pleura, related to the apex of the lung. It is deeply imbedded in the root of the neck and is palpated only with difficulty except in very thin people. Its costal cartilage joins with the sternum directly beneath the sterno-clavicular articulation, and is often found to be ossified early in life.

The second rib is similar to the first in position, but is much longer. At its head, it articulates with the lower border of the body of the first dorsal and with the upper border of the body of the second dorsal vertebra. It is curved somewhat downward toward its attachment to the sternum, making the first intercostal space wider anteriorly than posteriorly, but is not twisted upon itself. Its articulation anteriorly with the sternum is at the angle of Ludwig, which, being a very prominent landmark, is used to begin counting the ribs. Externally, it is covered by the superficial thoracic muscles, and internally, by pleura.

The third to seventh ribs, inclusive, are typical, and, with the exception of the increase in the twist of the shaft from above downwards, present no special features. Each articulates with two dorsal vertebrae at the head and with the transverse process of its corresponding vertebra, and anteriorly,

with the sternum. The increase in the twist of the rib makes an increase in the width of the intercostal spaces, the third interspace being the widest, the fourth slightly narrower, and the fifth and sixth approximately the same width anteriorly as posteriorly, this being due to the upward trend of the anterior extremity of the sixth and seventh ribs and their costal cartilages, to meet the margin of the sternum.

The tenth rib is very similar to the ninth, the main difference being that it articulates with only one vertebra, and that the tenth. Instead of presenting at its head two articular surfaces, it has only one for articulation with the upper border of the body of the tenth dorsal vertebra. Anteriorly, its costal cartilage joins with the cartilage of the ninth rib.

The eleventh and twelfth ribs do not articulate with their corresponding transverse processes and neither do they have an anterior articulation. This makes these two ribs very movable. Their articulation at the head is with the upper border of the body of the corresponding vertebra. The eleventh is longer than the twelfth and may always be palpated, while in some cases the twelfth is so short that, unless extreme care be used in examination, a patient may be suspected of having only eleven ribs. It may be entirely concealed beneath the heavy muscle fibers of the erector spinae mass. The lower border of the twelfth rib serves for the attachment of the quadratus lumborum muscle. It is of importance to remember this attachment in treatment applied in this region. Each of the last two

ribs terminate anteriorly in a pointed cartilage which serves for the attachment of muscles.

The sternum is a long flat bone, placed in the mid-line anteriorly and having the costal cartilages of the true ribs attached to its lateral margins. It is divided into three parts; manubrium, gladiolus and ensiform process. The manubrium is the uppermost part and supports the articulations for the clavicle, the first rib and one half of the articulation of the second rib. At its lower end, it articulates with the second part, or gladiolus, by means of fibro-cartilage that remains elastic until late in

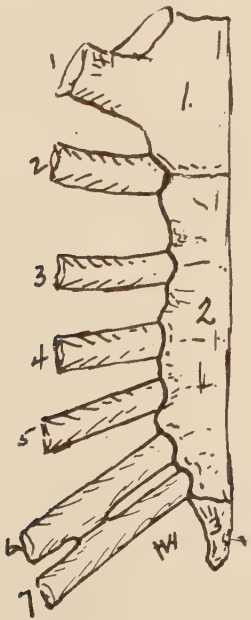
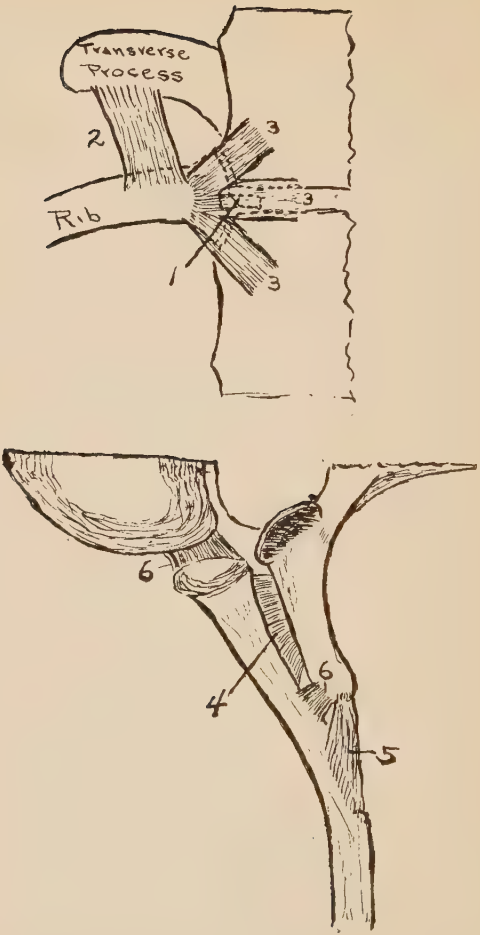


FIG. 32. One-half of sternum with cartilages of true ribs attached.



Figs. 33 and 34. The ligaments of the costo-vertebral and costo-transverse articulations. (1) Intertaricular, (2) Superior costo-transverse, (3) Stellate, (4) Middle costo-transverse, (5) Posterior costo-transverse, (6) Articular capsules.

life. The manubrium and gladiolus do not lie in the same plane but form an angle at the articulation which is quite prominent and easily palpated. This is known as the angle of Ludwig and marks the articulation of the second rib with the sternum. The gladiolus receives along its margin the articulations for one half of the second rib and the complete articulations of the costal cartilages of the remaining true ribs, that of the seventh often articulating with both the second part of the sternum and the ensiform process. The third part, or ensiform process, is an irregular cartilaginous structure, often bifid at the lower extremity, and may be bent to a greater or less degree in any direction. The sternum is covered for the most part both anteriorly and posteriorly by musculature, the pectoralis major being found anterior to it and the triangularis sterni posterior.

The ribs and their costal cartilages form with the vertebrae and sternum a series of six different articulations. These are all freely movable and unless the articulations are understood, it is impossible to appreciate the variations in movement of the ribs that may occur.

The Costo-vertebral Articulations

CLASS.—DIARTHROSIS. SUBDIVISION.—CONDYLARTHROSIS.

This is a perfect joint, formed by the head of the rib articulating with the body of the vertebrae. The typical arrangement is that a rib articulates with the upper border of the body of the corresponding vertebra and with the lower border of the body of the vertebra above. An exception must be made in

the articulations of the first, tenth, eleventh and twelfth ribs, as these articulate with their corresponding vertebrae only. Each costo-vertebral articulation is supported by three ligaments.

The capsular ligament is a strong mass of fibers completely enclosing the articulation. The posterior fibers extend into the spinal canal thru the intervertebral foramen and blend with the posterior common ligament. It is attached above and below to the bodies of the adjacent vertebrae, and its central portion is securely attached to the intervening intervertebral disc.

The interarticular ligament is found associated with the typical ribs only, not being present in the articulation of the first, tenth, eleventh or twelfth ribs. It consists of a mass of short, but strong fibers, extending from the interarticular crest of the head of the rib to the intervertebral disc, blending with the external lamina of the disc. This ligament completely separates the articulation into two parts, but is of sufficient length to allow of free motion, even to the extent of rotation on its own axis.

The stellate ligament is found associated with each costo-vertebral articulation and is unique in its arrangement. It may be divided into three parts, a superior, an inferior and a middle part. These are attached to the neck of the rib, lateral to the attachment of the articular capsule. The superior portion passes upward and is attached to the body of the vertebra above. The middle portion passes anteriorly and is attached to the intervertebral disc. The inferior portion passes downward and is attached to the body of the vertebra below.

Each of the three divisions, in passing to its attachment, is found anterior to the articular capsule.

The synovial membrane consists of two closed sacs separated by the interarticular ligament, the first, tenth, eleventh and twelfth being exceptions, and on account of the absence of the intervertebral ligament form one cavity.

The arterial supply is from the intercostal arteries, and the nerve supply from the corresponding spinal segment.

The Costo-transverse Articulations

This articulation is found between the tubercle of the rib and the tip of the corresponding transverse process and is present in all except the tenth and eleventh. These two ribs do not present a well-marked tubercle, and the corresponding transverse process is small. Four ligaments support the articulation.

The articular capsule is a thin loose mass of fibers, enclosing the synovial membrane, and is thickest inferiorly where it is not strengthened by other ligaments. Laterally, its fibers blend with the posterior costo-transverse ligament; superiorly, they blend with the superior costo-transverse ligament; and mesially, with the middle costo-transverse ligament.

The superior costo-transverse ligament is a strong, flat band of fibers, extending from the upper margin of the neck of the rib to the lower border of the transverse process of the vertebra above. Its anterior surface is in relation to the intercostal vessels and nerve.

The middle costo-transverse ligament is a band of short fibers found between the posterior surface of the neck of the rib and the anterior surface of the corresponding transverse process. Its margins extend from the costo-transverse articulation to the costo-vertebral articular capsule.

The arterial and nerve supply are from the corresponding intercostal artery and spinal nerve.

The costo-chondral articulations are synarthroses. The anterior extremity of the rib is concave and receives the convex end of the costal cartilage. No special ligaments are present, but the joint is maintained by the continuity of the periosteum and perichondrium.

The Chondro-sternal Articulations

CLASS.—DIARTHROSIS. SUBDIVISION.—GINGLYMUS.

These articulations are found between the costal cartilages of the second to seventh ribs, inclusive, and the lateral margin of the sternum. The chondro-sternal articulation of the first rib is synchondrodial and consequently not as freely movable as the other six of the true ribs. The cartilage of the first ribs is the first to ossify. The typical chondro-sternal articulations are supported by two well-defined ligaments.

The anterior radiate ligament is attached to the anterior surface and mesial half of the cartilage and spreads out fan-like to be attached to the anterior surface of the sternum.

The posterior radiate ligament is not so well-defined, but consists of fibers attached to the cartilage and radiating to the posterior surface of the sternum. Superior and inferior thickenings of this lig-

ament are often described as separate parts. An interarticular ligament is usually present in the articulation of the second costal cartilage with the first and second parts of the sternum, thus forming a double synovial sac. A chondro-ensiform ligament may be described as extending between the cartilage of the seventh rib to the ensiform process.

The first chondro-sternal articulation has no synovial membrane; that of the second rib is usually double; and a single synovial sac is found associated with the remaining articulations.

The blood supply is from the internal mammary artery, and the nerve supply, from the corresponding intercostal nerve.

The Interchondral Articulations

These articulations are found between the costal cartilages of the sixth to ninth ribs, inclusive.

Class.—Diarthrosis. Subdivision.—Arthrodia.

The seventh rib articulates with the sternum, and near the costo-chondral articulation, forms another joint with the cartilage of the sixth rib. The cartilage of the eighth articulates with the cartilage of the seventh, the ninth with the eighth, and the tenth with the ninth. These articulations are freely movable, each having a synovial sac and strengthened by a well-marked capsule.

The superior intersternal articulation is found between the first and second parts of the sternum and forms the angle of Ludwig. No synovial sac is present, but movement is established by the intervention of a thick plate of fibro-cartilage.

The inferior intersternal articulation is between the second and third parts of the sternum and is similar to the superior articulation.

Movements

One hundred and ten articulations are utilized in normal elevation and depression of the ribs, leaving out the possibility of movement between the dorsal vertebrae. Including a movement of flexion or extension in the dorsal region, there would be one hundred forty-six articulations involved. Referring again to the one hundred ten articulations of the ribs and sternum, we find that two of these are intersternal, twenty-six are synarthrodial, and the remaining eighty-two are diarthrodial, each having a synovial membrane. This series of articulations provides for free movement of the ribs, individually and collectively, and, at the same time, permits of impairment of movement at one or more points of articulation. The collective movement of the ribs and sternum, exclusive of the movement of the dorsal vertebrae, is that of elevation and depression and may be called the typical movement of the ribs. In these movements, there is rotation at the costo-vertebral articulation, the axis of which passes thru the costo-transverse articulation and thru the center of the interarticular ligament of the costo-vertebral articulation. Gliding movement occurs at the costo-transverse articulation, which is more marked in the lower ribs. The movement at the chondro-sternal articulations is of a ginglymoid character while that at the interchondral articulations is of the gliding variety.

FIG. 35. Dr. Halladay demonstrating the position of the ribs in deep inspiration or elevation.

Elevation.—In this movement, the rotation occurring at the costo-vertebral articulations produces a prominent lower margin of the head of the rib and a corresponding depression of the upper margin of the head. Tension is increased on the inferior portion of the stellate ligament and capsule, and the interarticular ligament is twisted. Very little change occurs in the position of the bony parts at the costo-transverse articulation of the upper ribs, but, of the lower six or seven, the tuber-

cle is seen to glide slightly downward and inward. The costal cartilages move upward with the anterior extremity of the ribs and produce the hinge-like movement at the chondro-sternal articulation.

FIG. 36. The position of the ribs in expiration or depression. Compare with figure 35.

The movement at the inter-chondral articulations is gliding and results in the cartilage of the lower rib gliding outward and slightly backward, thus increasing the diameters of the base of the thorax. This movement changes the size of the intercostal

spaces only slightly, but does increase all diameters of the thorax.

Depression.—This is not as marked a movement as elevation, taken, as is elevation, from a position of rest. The rotation occurring at the costo-vertebral articulation is not so marked, but results in a prominence of the upper border of the head of the rib and increased tension on the upper part of the capsule and stellate ligament. The gliding movement is relatively the same at the costo-transverse articulation, being more marked in the case of the lower ribs. The costal cartilages are depressed and directed downward from their chondro-sternal articulations. The gliding occurring at the inter-chondral articulations is inward and forward, lessening the diameters of the base of the thorax. The inclination of all the ribs is increased, and this movement is accompanied by a slight amount of flexion of the dorsal region. The angle of Ludwig may be obliterated, and the first and second parts of the sternum be found in the same plane.

Regarding combined movement with the dorsal region, it is noted that flexion of the dorsal vertebrae produces depression of the ribs, but does not interfere with elevation. Extension in the dorsal region produces some elevation of the ribs and interferes with depression.

Rotation and side-bending in the dorsal region lessen depression, but have very little, if any effect upon elevation. In rotation and side-bending in the dorsal region, the ribs on the side of the concavity are slightly depressed, while on the side of the convexity they are slightly elevated. A concavity

and convexity are produced in the sternum, the bending occurring at the superior intersternal articulation and conforming to the dorsal curve.

Analysis of the movement occurring in elevation and depression of the ribs shows that it is a combination of two movements either of which may occur separately. In increasing the antero-posterior diameter of the thorax, the anterior extremity of the rib is raised, the axis of the movement passing thru the costo-transverse and costo-vertebral articulations. In normal movement, lateral expansion is associated with the antero-posterior increase. This is affected by movement occurring thru an axis passing thru the costo-vertebral and chondro-sternal articulations. The common terms for these movements are "pump-handle" and "bucket-bail", respectively. This brings us to the individual movement of the ribs which may occur thru either

Fig. 37. Sagittal axis of movement of the ribs a-b. Oblique axis, c-d.

Fig. 38. Dr. Halladay demonstrating the movement of the fourth rib in its sagittal axis.

axis of movement. The anterior-posterior axis of movement will be referred to as the sagittal axis, and that passing thru the costo-transverse and costo-vertebral articulations will be called the oblique axis.

The first rib moves freely thru its sagittal axis, but is limited in movement thru its oblique axis. This latter is due to the short costal cartilage and the form of its costo-chondral and costo-sternal articulations, being of the synarthrodial variety.

Unilateral elevation of the first rib predisposes to rotation-side-bending lesions of the first dorsal vertebra on the second, the dorsal spinous process being found slightly rotated to the side of the elevated rib. Depression of the first rib produces depression of the first part of the sternum, making the angle of Ludwig more prominent. Movements of the second rib are associated with the first on account of both articulating with the first part of the sternum and being acted upon from above by the same set of muscles.

The second rib moves freely in either axis. Its costal cartilage is longer than that of the first and its articulation with the sternum is of the diarthrodial variety. Movement thru either axis may be impaired, but is easily diagnosed. As stated above, it is associated with movements of the first rib and sternum.

The third, fourth and fifth ribs show free, independent movement in either axis. This is provided for in the attachment of the serratus posticus superior and pectoralis minor muscles.

The sagittal axis of the sixth rib changes slightly anteriorly. In this case, it passes thru the costovertebral and interchondral articulations of the sixth and seventh ribs. This arrangement does not limit the movement in this axis, but, on account of the joining of the cartilages of the sixth and seventh ribs, limits the movement in the oblique axis, unless it is accompanied by similar movement of the seventh rib.

The movements of the seventh rib are similar to those of the sixth on account of their attachment

to each other. Elevation of the seventh rib produces elevation of the eighth, due to the interchondral articulation of the eighth cartilage.

The eighth, ninth and tenth ribs move freely in either axis. The inter-chondral articulations are of the gliding variety and do not limit any form of motion. Elevation of one rib produces some elevation of the one below.

The eleventh and twelfth ribs are freely movable, their motions not being confined to the axes described. Each may move independently of the other, but it is commonly found that depression of the twelfth rib, due to contracture of the quadratus lumborum muscle, is followed by some degree of depression of the eleventh also.

Diagnosis

This division of the discussion must take up the individual ribs, as some are easily palpated, while others are found with difficulty, and, in case of the first rib, it is only rarely that it may be located with certainty.

Lesions of the first rib most commonly occur in movement thru its sagittal axis. Thus it is spoken of as being "up" or "down", when really it is elevated or depressed. The costal cartilage of the first rib may be palpated beneath the sternal end of the clavicle. At its costo-chondral articulation, it turns suddenly backward and is found directly inferior to the clavicle and covered by the subclavius muscle. Posterior to the subclavius, it is crossed by the subclavian vein, posterior to which is the insertion of the scalenus anticus muscle. Posterior

to the scalenus anticus, the rib is crossed by the subclavian artery and the first dorsal nerve. This brings us to a small rough triangular area between the subclavian groove and the tubercle of the rib to which is attached the scalenus medius muscle. The fibrous insertion of the scalenus medius is often mistaken for the lateral margin of the first rib, and many cases have been treated for elevated first rib following this diagnosis. The outer margin or neck of the first rib may be palpated in thin people and is best proved by placing the fingers deeply in the root of the neck and then pressing downward and inward on the cartilage anteriorly. SYMPTOMS show more plainly the possible lesions of the first rib than PALPATION. In elevation of the first rib, the brachial plexus will be involved; and in depression, the intercosto-humeral nerve. Tenderness in the region of the spinous process of the first dorsal may indicate a lesion of the first rib, but may be found associated with other conditions also. The neck or tubercle cannot be palpated posteriorly on account of the dense mass of musculature covering the structures.

The second rib is easily found and palpated anteriorly, being located on a line with the angle of Ludwig. In cases of prominence of its cartilage or the cartilage of any of the true ribs, it may be in lesion, the oblique axis being affected. Its lower border may be palpated in some cases in the axillary space. Posteriorly, the tubercle of the second rib is on a level with the tip of the transverse process of the second dorsal vertebra and may be palpated in cases of poorly developed musculature.

Posteriorly, the tubercles of the fourth and fifth ribs may be palpated and should be found on a level with their corresponding transverse processes. These ribs may be followed to their anterior attachment, which may be easily found in relation to the margin of the sternum.

The tubercle and upper border of the neck of the fifth rib are found slightly above the level of the transverse process of the fifth dorsal vertebra. The rib may easily be followed to its attachment to the sternum.

The tubercles and upper borders of the necks of the remaining ribs are found from three-eighths of an inch to one-half inch above the corresponding transverse processes, and may be easily palpated. With the exception of the twelfth rib, they may all be followed to their anterior extremities. Lesions of the cartilages of the false ribs often occur, and such lesions cause nerve disturbance in the abdominal region, especially of the muscles of the anterior abdominal wall. Very deep palpation is sometimes necessary in order to locate the twelfth rib, on account of its variation in length. The pointed cartilaginous tips of the last two ribs may be displaced and result in a great deal of irritation to the surrounding structures.

It must be remembered that the ribs may move independently of the dorsal vertebrae and are therefore subject to primary lesions, but they always move with the dorsal vertebrae, and such being the case this point is valuable in the diagnosis of dorsal lesions. In rotation-side-bending lesions, the ribs are found approximated on the side of the

concavity and separated on the side of the convexity. This may apply to two or more ribs: two ribs being approximated indicates, in many cases, a single dorsal lesion; several ribs approximated would indicate a group lesion.

The ribs and their interspaces serve as important landmarks, the most important of which should be kept in mind. Heart sounds are heard in the second interspace both on the right and the left sides, and in the fifth interspace on the left side. The area from the fourth to sixth costal cartilages on the left marks the cardiac notch of the lung. The sixth chondro-sternal articulation on the right marks the extent of the pericardium at its lowest level on the right, and also the anterior angle of the pleura. The same point on the left is in the same plane as the cardiac opening of the stomach. The junction of the ninth costal cartilage with the eighth on the right locates the gall-bladder. The scapula is found from the second to the seventh ribs posteriorly. The spleen is crossed by the tenth rib on the left side. The kidneys are bisected obliquely by the twelfth ribs. The upper border of the sternum is in the same horizontal plane as the intervertebral disc between the second and third dorsal vertebrae. The distal extremity of the ensiform process marks the level of the intervertebral disc between the tenth and eleventh dorsal vertebrae. The pleural cavity may be entered in the mid-axillary line in the eighth interspace without injury to the lung.

Structures Affected

Bone.—No great variation is found among the ribs individually. This is no doubt due to the

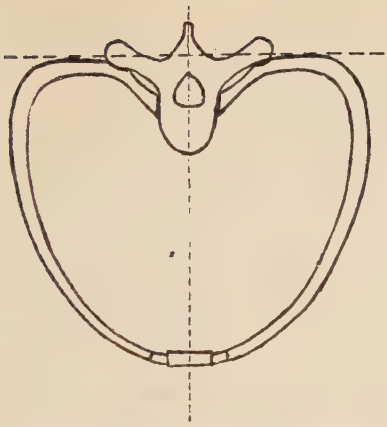


FIG. 39. The relative position of the typical rib and its corresponding vertebra at rest.

fact that they as a rule move together and depend for their support upon the dorsal vertebrae and the sternum. The greatest variations are noted, then, where deformity is found in the dorsal vertebrae and in the sternum. The greatest deviation noted in the laboratory is in the slight variation in the relative position of the first and second ribs as compared to the remaining ten. This variation is noted at the vertebral end of the rib by a change in the curve beginning at the junction of the shaft with the neck. In such cases, the movement does not seem to be impaired greatly, but is limited on account of the twist of the region.

The eleventh and twelfth ribs, altho the most movable, are rarely found to be separately affected. On account of their similarity, if one is displaced, it will affect the other to a certain extent.

Deformity of the ribs as a whole is most commonly found associated with scoliosis. On account of the lateral flexion and rotation occurring in the dorsal region in this condition, the pressure is increased on the ribs on the side of the concavity, which results in a straightening of the angle, the opposite being true on the side of the convexity. Other conditions that tend to cause deformity of the ribs are pulmonary tuberculosis and emphysema. In tuberculosis, there is depression of the ribs with increase in the normal twist, resulting in the "flat-chest" so commonly noted in this condition. In emphysema, we note the increase in all thoracic diameters with the ribs found in a more horizontal plane and a decrease in the normal twist of the rib on its long axis.

Lesions affect the bony structure of the rib at the point of articulation only, and, according to the

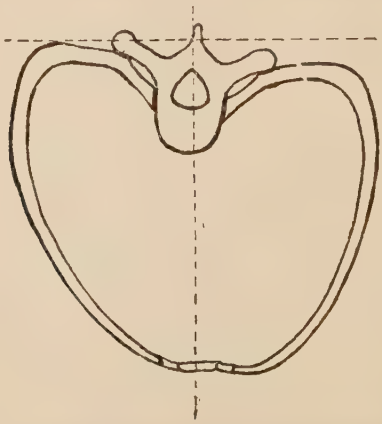


FIG. 40. Showing the effect of rotation of the vertebra upon the position of the rib.

laboratory findings, these take the form of exostotic growths around the margin of the articular surface. The articulation of the head of the rib with the body of the vertebra is most often the seat of these growths and is undoubtedly due to the fact that free movement is found at this joint, that it takes part in all movements of the ribs, that it is subject to the greatest strain, when pressure is applied to a rib, and is typically a double articulation, being affected by the position of two vertebrae. The neck of the rib occasionally shows a bony growth which is the result of the ossification of the middle costo-transverse ligament. This is rarely complete and, when so, is associated with ankylosis of the vertebrae adjacent. Some variation is noted at the tubercle, especially of the lower ribs, whose tubercles are found at a slightly higher plane than those above. In some cases, these seem to be enlarged and rough, indicating the possibility of previous irritation in the form of increased pressure at the articulation. The articular surface is not impaired, but the increase in osseous tissue prevents the normal gliding of the joint. Slight variation of the width of the various ribs in different subjects is noted. This condition is difficult to explain, but can, by comparison, be traced to the variations noted in individuals, as applied to other bony structures. This may be applied to the variation noted in the inclination and twist of the shaft as found in many cases. Injury to the thoracic wall frequently results in deformity of the ribs, especially if complete fracture results. In cases of direct trauma resulting in fracture, the end of one fragment will be more prominent than the

other and, if not set properly, will produce an enlargement along the shaft that will not absorb and may be easily palpated. In case of fracture due to indirect trauma, the rib is usually splintered and not completely broken thru. Repair in these cases, unless properly cared for, will result in compression of the chest wall and a knob-like exostotic growth at the point of fracture. In cases of fracture of several ribs, ankylosis may occur resulting in obliteration of the intercostal space along the line of fracture and in an area of immobility of the thoracic wall.

The costal cartilages, on account of their elasticity, follow the movements of the ribs to which they are attached and are twisted or bent with the rib. Variations in intrathoracic pressure and certain diseases produce deformities of the cartilages that seem to be out of proportion to the effect shown on the ribs. This, however, is due to the greater elasticity of the cartilage. Examples of this may be noted in rickets, scoliosis and aneurism of the arch of the aorta. The cartilages of the eighth, ninth and tenth ribs may be displaced and, if so, will result in great irritation. Abnormalities of these cartilages may cause spasm of the diaphragm or abdominal muscles, or the irritation may be cutaneous, having affected the terminal branches of the intercostal nerves. Occupations requiring pressure to be exerted upon the sternum or cartilages are often the cause of deformity. In the laboratory, the tenth rib is often found to be a floating rib, and several cases of cartilage of the eighth rib attached to the sternum have been found. These conditions are not associated with supernumerary ribs.

The sternum depends upon the ribs and their cartilages for its position and is, then, subject to change in position and form with variations of the ribs. Occasionally a congenital deformity of the sternum is noted, which usually takes the form of foramina in the gladiolus in the mid-line. Some of these are quite large and may show the pulsations of the heart. Lesions may occur between the first and second parts of the sternum and are attended by loss of movement in the dorsal region and of the upper extremity. The ensiform process is very irregular in size, shape, and position, as it is found bent in various directions. Quite a few cases of the ensiform being bent inward have been noted. This may be due to the muscular pull or to pressure from tools, required in some occupations. It may be deflected to the right or left, and some few cases are found where it is bent outward, resulting in irritation to the skin over it.

It must be remembered that the upper extremity is supported by the sternum thru the sternoclavicular articulation, and that the clavicle may be affected by abnormalities of the thorax. These are in the form of an increase or decrease in the curves of the clavicle.

Ligaments.—The ligaments binding the articulations of the ribs and sternum are subject to the same strains as other similar structures, and their injury results in the formation of scar tissue or thickened ligaments. The ones most often involved are those associated with the more movable articulations, as the stellate and interarticular of the costo-vertebral articulation, and the superior and

posterior of the costo-transverse articulation. Partial ossification of these ligaments is often noted in the laboratory and is associated with other evidence of lesions of the rib or adjacent vertebrae. The stellate ligament is in direct relation to the lateral chain ganglia of the involuntary nervous system, and any injury affecting this ligament may cause irritation to this important series of nerves. The superior costo-transverse ligament is in direct relation to the intercostal nerve and abnormalities of it may result in intercostal irritation. Impaired movement is the first indication of affected ligaments.

Muscles.—The muscles effecting movement of the ribs and sternum will be discussed, as for other regions, from a standpoint of function only. Any muscle attached to a rib or ribs will have some effect upon the movement of the rib or ribs, either in the production of movement or in fixing the rib or ribs, in order that some other muscle may act.

SERRATUS POSTICUS SUPERIOR.—Elevates the second, third, fourth and fifth ribs.

SERRATUS POSTICUS INFERIOR.—Depresses the lower four ribs.

ILIO-COSTALIS LUMBORUM.—Depresses the ribs, acting principally upon the lower six.

ILIO-COSTALIS DORSI.—Approximates the upper and lower ribs.

ILIO-COSTALIS CERVICIS.—Elevates the ribs, acting principally upon the upper five or six.

LONGISSIMUS DORSI.—Aids in depressing the ribs.

LEVATORES COSTARUM.—Elevates the ribs.

SCALENUS ANTICUS.—Raises the first rib.

Scalenus medius.—Raises the first rib.

Scalenus posticus.—Raises the second rib.

Sterno-mastoid.—Assists in raising the sternum, if the head and neck are fixed.

Infra-hyoid group.—Assists in raising the sternum, if the hyoid bone is fixed.

Serratus magnus.—Assists in raising the lower ribs, if the scapula is fixed.

Pectoralis major.—The lower fibers assist in raising the ribs, if the arm is fixed.

Pectoralis minor.—Elevates the second, third fourth and fifth ribs, if the scapula is fixed.

Triangularis sterni.—Draws the anterior extremity of the ribs downward.

Rectus abdominis.—Depresses the ribs and sternum.

External oblique.—Depresses the ribs, acting principally upon the lower five or six.

Internal oblique.—Depresses the ribs, acting principally upon the lower five or six.

Transversalis.—Both muscles acting depress the lower ribs.

Quadratus lumborum.—Draws the twelfth rib downward.

Intercostals.—Approximate the ribs.

Diaphragm.—To pull the cartilages of the lower ribs inward, unless they are fixed.

Arteries.—The subclavian artery passes directly over the first rib and lies in a groove on its upper surface. This is an important relation, as the artery may be interfered with by abnormal position of the first rib and may be compressed against the rib by pressure from above downward. The intercostal

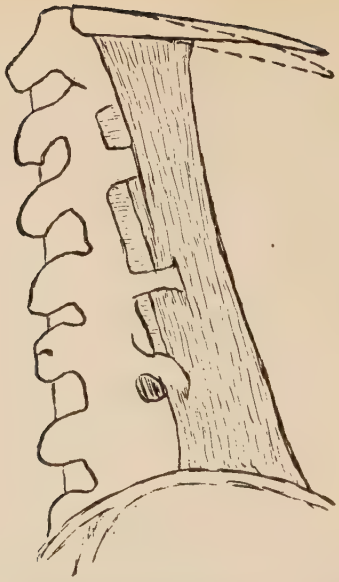


FIG. 41. The quadratus lumborum muscle and its action upon the twelfth rib.

arteries are found directly beneath the rib for which they are named. At their origin from the aorta, they pass at first backward to the attachment of the superior costo-transverse ligament and then pass laterally upon the anterior surface of the ligament to enter the intercostal space. These may be affected at any point along their path by abnormalities of the musculature or of the ligaments with which they are in contact. Lesions of the twelfth rib affect the subcostal artery, as it passes along its lower border. In the axillary region, the thoracic branches of the axillary artery may be compressed against the thoracic wall by pressure of growths or foreign ob-

jects. The internal mammary artery is found along the margin of the sternum beneath the costal cartilages and may be injured by penetrating wounds at the anterior extremity of the intercostal space. It freely anastomoses with the intercostal series of arteries in the upper spaces and, by means of its musculo-phrenic branch, with the lower intercostals. The aorta should be mentioned not on account of its relation to the ribs normally, but as in cases of aneurysm of the thoracic aorta, the ribs on the left side suffer, often being found to be completely destroyed by the pressure.

Veins.—The subclavian vein passes over the first rib anterior to the subclavian artery. It is easily compressed by an upward inclination of the first rib and results in congestion of the upper extremity. The intercostal and subcostal veins bear the same relation to the ribs as the corresponding arteries. They are found between the musculature in each intercostal space and will be affected by abnormalities of the adjacent structures. The venae commites of the internal mammary artery form an important venous anastomosis between the superior and inferior venae cavae. Free drainage thru the inferior thyroid plexus of veins is interfered with in case of depressed manubrium. The venae azygos system may be easily interfered with and the drainage from the spinal cord interrupted in cases of thoracic lesions. These veins are found in intimate contact with the head of the ribs.

Nerves.—Lesions of the first rib will interfere with nerve impulses carried over the first dorsal segment to the brachial plexus. This part of the

first dorsal nerve passes upward and outward over the neck of the first rib and there joins with the eighth cervical nerve, and as the lower trunk of the brachial plexus, passes over the first rib slightly posterior and below the brachial artery. An increased tension on this trunk will result in irritation to the internal anterior thoracic, internal cutaneous, lesser internal cutaneous, median, musculo-spiral, ulnar, or first intercostal nerves, as they have part of their origin from this segment. Thus, many cases of brachial neuritis may be traced to lesions affecting this segment. The intercosto-humeral nerve is the lateral cutaneous branch of the second intercostal and is affected by lesions of the first or second rib, passing out in the axillary space between them. This nerve supplies the skin of the axillary space and assists in the supply of the upper and inner part of the arm. The intercostal nerves are

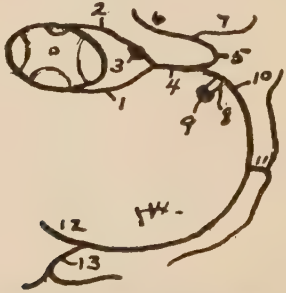


Fig. 42. A typical spinal nerve and its parts. (1) Anterior nerve root, (2) Posterior nerve root, (3) Ganglion on posterior nerve root, (4) Mixed spinal nerve, (5) Posterior primary division, (6) Internal branch of posterior primary division, (7) External branch of posterior primary division, (8) Grey and white rami communicantes connecting the lateral chain series of ganglia with the spinal nerve, (9) A ganglion of the lateral chain, (10) Anterior primary division, (11) Lateral cutaneous branch, (12) Anterior muscular branch, (13) Anterior cutaneous branch.

subject to irritation as they pass into the intercostal space in relation to the superior costo-transverse ligament, again in the region of the mid-axillary line where the greatest amount of movement of the ribs occurs, and again in relation to the costal cartilages, especially those of the lower ribs. The effect is to produce sensory and motor disturbances in the intercostal region, and in case of the lower intercostals in the abdominal region also. The ilio-hypogastric and ilio-inguinal nerves may be irritated by lesions of the twelfth rib on account of the close relation of the nerves at their origin.

The most commonly affected system of nerves in this region is the lateral chain of the involuntary nervous system. This series of ganglia and their interganglionic fibers pass in direct relation to the stellate ligaments of the ribs and are therefore easily disturbed by rib abnormalities. This important series of nerves gives off branches distributed to all parts of the body, and some of the effects of rib lesions are in truth very far-reaching. Any of the many impulses originating over the thoraco-lumbar cord may be interfered with.

Viscera.—The thoracic viscera affected by abnormalities of the ribs and sternum are the heart and lungs. Normally, the lungs are grooved on their outer surface by the ribs and, in cases of any increase in the pressure, the function will be decreased in proportion. Fractures of the ribs frequently injure the delicate lung tissue. The heart is not in direct relation to the ribs, but is in relation to the sternum and some of the costal cartilages. There may be injuries and growths affecting the heart by pressure. In cases of scoliosis, the position of the

heart and lungs is affected, all thoracic viscera being forced to the side of the convexity. The liver in the abdominal cavity is affected by abnormalities of the lower ribs on the right side. It is not unusual to see grooves on the lateral surface of the liver for the lower three or four ribs. These, however, are much more prominent where compression of the lower ribs has occurred and affected the shape and position of the liver to a great extent. On the left side, the spleen is crossed by the tenth and eleventh ribs. Its position may be affected by abnormalities of either of these named ribs. The kidneys are crossed on either side by the twelfth ribs. Lesions of this rib or of the softer tissues in this region may affect the kidney. The stomach may be affected by abnormalities of the ensiform process, as it is found in some cases to be turned in, so that its pointed extremity is directed internally. This serves as a constant source of irritation to the abdominal wall and to the stomach when distended.

Movement.—Movement of the ribs is controlled by a number of factors, each of which must be taken into consideration: muscles, on account of their normal function; gravity plays an important part in all movements of the thorax; and the presence of pathological conditions which interfere with normal movement of a part or parts. The movements should be free, as described, and without discomfort. Age, sex, and weight will each influence the mobility of the ribs to a certain extent. Diagnosis must be made carefully, keeping in mind the structures, as they should be found normally, and the possible variations occasionally met with, but not classed as pathological.

CHAPTER VI.

THE LUMBAR REGION

The lumbar vertebrae are five in number and are distinguished by their large size, the absence of the facets for articulation of ribs, and absence of the transverse or vertebral foramina. The body of the typical lumbar vertebra is kidney-shaped, the concavity being directed posteriorly, making the transverse diameter the greatest. The superior and inferior surfaces are flat, but are not found in the same plane, as the body of the vertebrae in this region are slightly deeper anteriorly than posteriorly, thus aiding in the formation of the lumbar curve which is convex anteriorly. The pedicles which extend posteriorly are short and strong and are attached to the body above its center, making the in-

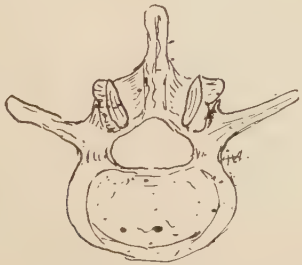


Fig. 43. Superior surface of typical lumbar vertebra.

ferior vertebral notch the larger. The laminae are very short and thick, and support, at their upper border, the superior articular processes and, at the lower margin, the inferior articular processes. The spinous process is thick, broad and blunt at its extremity, the inferior border being thicker than the superior. The superior articular process projects above the level of the upper surface of the body and supports the mammillary process which corre-

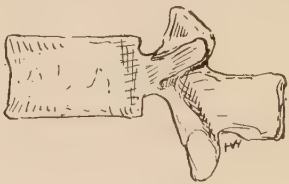


FIG. 44. Lateral view of typical lumbar vertebra.

sponds to the superior tubercle of the transverse process of the twelfth dorsal. The articular surface is directed inwards and slightly backwards in a vertical plane and encloses the inferior articular facets of the vertebra above. The inferior articular process extends below the level of the lower surface of the body; its articular surface is directed outward and slightly forward in a vertical plane. The transverse processes are slender and flattened antero-posteriorly and project outwards and slightly backwards in a horizontal plane. The transverse processes of the third are usually the longest, and those of the first are the shortest. The transverse process is the costal element in the lumbar region and may support an articulated tip of varying length which is called a lumbar rib. The fifth lumbar is

classed as a peculiar vertebra on account of the wedge-shape of the body, it being very shallow posteriorly. This condition approximates the fourth lumbar spinous process to the first spinous process of the sacrum and results in a reduction in size of the spinous process of the fifth lumbar. This condition makes palpation of the fifth lumbar spinous process difficult.

The ligaments in the lumbar region are the same as in the other regions of the spine, the anterior and posterior common and interspinous ligaments being continouus. Special ligaments are found in relation to the lumbo-sacral articulation, connecting the fourth and fifth lumbar vertebrae with the sacrum.

The typical lumbar articulations begin with the articulation between the twelfth dorsal and the first lumbar vertebrae and include that between the fourth and fifth lumbar vertebrae. These articulations correspond in general structure to those of the dorsal and cervical regions, in that there is a central joint, a synchondrosis, formed by the intervertebral disc between the bodies. This disc should be noted in relation to the last two lumbar articulations on account of its great depth anteriorly, being from one-half to three-fourths of an inch in thickness. Laterally, the articulations between the articular processes are similar to those in the dorsal and cervical regions, differing mainly in the size and plane of the articular surfaces.

The lumbo-sacral articulation differs slightly from the typical lumbar articulation; it is of the same formation, the two bony structures being in relative

position, and the articulations are of the same class. The intervertebral disc between the fifth lumbar and sacrum is the largest in the series, being broader and thicker, especially anteriorly. This allows free movement in practically all directions. The articular capsules and other ligaments are similar or continuous as in other parts of the spine. In addition to the more common ligaments, are found the

Fig. 45. The ligaments of the lumbo-sacral articulation.

sacro-lumbar and ilio-lumbar ligaments. The sacro-lumbar ligament is a strong mass of fibers attached to the transverse process of the fifth lumbar anteriorly and may extend mesially onto the pedicle and body of the vertebra. It passes downward to a fan-like expansion, being attached to the periosteum over the anterior surface of the sacrum and laterally blending with the superior sacro-iliac ligament.

The ilio-lumbar ligament is attached above to the transverse processes of the fourth and fifth lumbar vertebrae; that portion found between the

transverse processes is intimately blended with the intertransverse ligament. It passes downward and outward, being attached to the inner lip of the crest of the ilium posteriorly for about two inches. These ligaments prevent lateral movement in the opposite direction beyond the normal range, and add strength to the articulation.

Movements

Flexion and extension.

Lateral flexion or side-bending.

Flexion or forward-bending is a free movement in the lumbar region; it is not evenly distributed, but increases from above downward, the greatest amount of movement being found between the fifth lumbar and the sacrum. In this movement, there is separation of the spinous processes, those of the fourth and fifth lumbar and first sacral being the most widely separated; the laminae are separated and the ligamenta flava is tensed; there is slight separation of the transverse processes; the posterior portion of the intervertebral disc will be relaxed and the anterior portion compressed. The intervertebral discs below the fourth and fifth lumbar project anteriorly, forming a marked ridge between the bony segments. The convexity of the lumbar curve will be obliterated. This does not show in all cases along the anterior margin of the bodies of the vertebrae, but will be if taken along the line of the articular processes. The articular processes are separated by a gliding movement, occurring in the vertical plane of the facets, the inferior margin of the inferior articular process becoming slightly more prominent. This movement occurs in the sagittal plane as a segment

of a sphere the center of which is near the anterior border of the body of the vertebra below and the circumference passing thru the anterior margins of the articular facet. The intervertebral foramina are greatly increased in size during flexion.

Extension is also a free movement in the lumbar region. The spinous processes are approximated and press tightly against each other. So great is the pressure that, in many cases, laboratory findings show marked changes in these bony structures. The laminae are approximated also, but not to such a degree as to result in direct relationship. The inferior extremity of the inferior articular process presses against the bone at the upper margin of the junction of the spinous process and lamina of the vertebra below. Compression of the intervertebral disc occurs posteriorly, and stretching anteriorly, with tension on the anterior common ligament. This movement occurs thru the same axis as in flexion, being confined to the sagittal plane and without antero-posterior movement or rotation. The intervertebral foramina are decreased in size in extension.

Lateral flexion or side-bending is an evenly distributed and free movement in the lumbar region, and is not accompanied by rotation. This fact has been demonstrated in the laboratory. Slight rotation may occur as a forced movement, but as a normal movement accompanying side-bending, as it is found in the dorsal and cervical regions, it does not exist in the lumbar region. The spinous processes in side-bending form an even curve with no appreciable change in the distance between them.

Fig. 46. Dr. Halladay demonstrating side-bending in the prepared spine.

On the concavity of the curve, the spinous processes form a smooth curved line, but on the convexity, on account of the lower border of the spinous process being heavy, they form a slight projection which may be palpated. The inferior articular processes move downward on the side of the concavity and upward on the side of the convexity. There is separation of the transverse processes on the side of the convexity and approximation on the side of the concavity. The intervertebral disc is compressed

and projects on the side of the concavity and is tense on the convex side. The intervertebral foramina are reduced on the concave side and increased in size on the side of the convexity, thus following a rule which applies to all regions. Side-bending decreases with the degree of flexion, there being very little possible in extreme flexion, both inferior articular facets being at their highest point of possible normal movement. Extension decreases side-bending, but not to such an extent as flexion.

Certain variations are found in a small per cent of the cases in the lumbar region which make rotation possible. The position of the articular facets of this region tends to prevent rotation, but, in a few cases in the laboratory, the articulations between the fourth and fifth lumbar and the lumbo-sacral articulation show a slight amount of rotation as a normal movement. This condition is more commonly found at the lumbo-sacral articulation, but even then in only about twenty per cent. of cases, and these with varying degrees of rotation. In some cases the lumbo-sacral facets simulate the dorsal, and in others the cervical facets, which will, depending upon the plane of the articular surface, allow of a greater or less degree of rotation. This is not the typical condition, but, on account of being found in a number of cases, must be taken into consideration in the possibilities of movement. Hypermobility is present at the lumbo-sacral articulation normally, that is, there will be found at this joint a greater degree of flexion, extension and side-bending than at any other single lumbar articulation. Then, in the cases where rotation is also pres-

ent, the movement is further increased. The rotation occurring in this articulation is associated with side-bending, and the relations of the bony parts are the same, comparatively.

Diagnosis

Accurate diagnosis in the lumbar region is difficult in many cases. The lumbar spinous processes are blunt and thick, and in many cases very irregular. In extension, it is extremely difficult to palpate the spinous processes, especially that of the fifth lumbar. In flexion, unless the individual is very stout or heavily muscled, they may be palpated easily. It is best, then, to begin palpation of this region in flexion. Following this with a backward-bending of the spine, there should be approximation of the spinous processes; if no movement occurs and the separation remains between any two or more spinous processes, the articulation is held in a position of flexion. This results in an undue prominence of the immobile spinous processes and is, as has been mentioned above, referred to as a "posterior condition". If, in this backward movement, two or more spinous processes remain approximated, they are held in extension and have been referred to as "anterior". On account of the thick muscular mass in the lumbar region, the transverse processes cannot be palpated with any great degree of success. The transverse process of the third lumbar is the most prominent, the others are irregular, so we must depend upon the spinous processes in order to determine the movement of lateral-flexion or side-bending. This diagnosis should be made in the position of flexion in order to make the

spinous processes as prominent as possible. In side-bending, the lower border of the spinous process of the vertebra above will be prominent on the side of the convexity. The lower border of this same spinous process may not be palpable on the concave side, as the greater smoothness of the curve is felt on the side of the concavity. Rotation, when present, will be slight, but may be determined by the prominence of the spinous process on the side of the convexity, its lower border being more prominent than its upper.

The lumbar spinous processes should be remembered as important landmarks in locating the articulations. Laboratory findings determine these relations as follows:

The spinous process of the first lumbar is in the same plane as the articulation between the first and second lumbar and the transverse process of the second lumbar vertebra.

The spinous process of the second lumbar is in the same plane as the articulation between the second and third lumbar and slightly above the level of the transverse process of the third lumbar.

The spinous process of the third lumbar is in the same plane as the articulation between the third and fourth lumbar and slightly above the level of the transverse process of the fourth lumbar.

The spinous process of the fourth lumbar is in the same plane as the articulation between the fourth and fifth lumbar and slightly above the level of the transverse process of the fifth lumbar.

The spinous process of the fifth lumbar is in the same plane as the articulation between the fifth lumbar and the sacrum.

Structures Affected

Bone.—A great many abnormalities are found in the lumbar vertebrae. This is due to the weight they must bear and the strain they are often subjected to. Ankylosis, while not common, is occasionally found and is associated with a similar condition in the lower dorsal region. Exostotic growths on

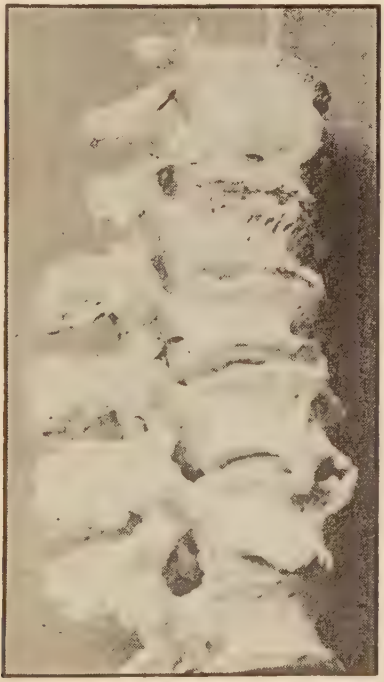


Fig. 47. Laboratory specimens showing ankylosis and exostosis in the lumbar region.

the bodies occur most frequently on the third and fourth lumbar and are found on the side rather than on the anterior surface. The bodies show evidence of compression in many cases which has resulted in a wedge shape. The spinous processes are irregular and show evidence, in many cases, of pressure by the adjacent spinous process. In cases of this kind,

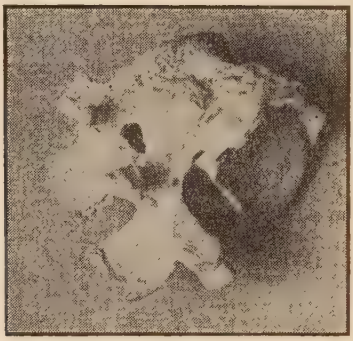


FIG. 48. Laboratory specimen showing ankylosis of third and fourth lumbar.

the lower border of a spinous process will be grooved to receive the narrow superior margin of the vertebra below. This causes an overgrowth of the bone along the inferior margin of the spinous process, and this will often lead to mistaken diagnosis of the position of the vertebrae. In a number of such cases, a rather well-defined joint appears between the upper border or one spinous process and the lower border of the other. The articular processes often show evidence of lesion. Under normal conditions these should be symmetrical. The articular facets are often rough, indicating a lack of normal movement. Also the tip of the articular process of one

side may project beyond the level of the one opposite, thus limiting the extent of movement on the side of the longer process. Inferior articular processes are often found pressing upon the base of the spine of the vertebra below, indicating that more weight has been borne on that side. The transverse process in the lumbar region is the true costal process and is found articulating with the body of the vertebra. This is most commonly found associated with the first lumbar. Another variation noted and often found is an articulated tip to the transverse process of the first and sometimes the second lumbar. Scoliosis confined to the dorsal region will show to some extent in the lumbar. The loss of normal balance must be made up above and below the primary curve, and on account of the lumbar region bearing the weight of all above it, it must respond to

Fig. 49. Laboratory specimen showing Pott's disease affecting all the lumbar and the four lower dorsal vertebrae.

FIG. 50. Laboratory specimens showing exostosis and the effect of scoliosis.

any variation in the position of the bony structures above. The spinous process of the fifth lumbar is normally small and difficult to palpate. In a few cases noted, it has been more prominent than the fourth. This condition should be watched for in the individual.

Intervertebral Foramina. — The intervertebral foramina in the lumbar region are large and

Fig. 51. Exact size of lumbar intervertebral foramen. The larger in extreme flexion, the smaller in extreme extension.

almost round. There is, however, a great variation in their size during the movements possible in this region. The foramen is largest in flexion and smallest in extension, there being a difference of about thirty-five per cent between the two. On the side of the convexity, the foramen is large and elongated and, on the side of the concavity in side-bending, the foramen is small and rounded, as it is in similar movements in the regions above. No change is felt in the size of the foramen during the small amount of rotation possible in some few cases.

Ligaments.—The ligaments in the lumbar region suffer in the same way as in other regions of the spine. The anterior common ligament is especially subject to great strain and in this region is thickened to strengthen the region. Its fibers, especially those passing over the lumbo-sacral articu-

lations, are very heavy and are often found bunched in small masses, showing evidence of partial rupture and healing. The interspinous ligaments are found thickened and very tough; many times, or in case the spinous processes are abnormally close, they may be almost obliterated. Great variation exists in the special ligaments of the lumbo-sacral articulation. The ilio-lumbar is often found to be partially ossified and in some few cases is apparently a part of the transverse process of the fifth lumbar and forms a crude articulation with the ilium. This condition can undoubtedly cause a great deal of irritation to the individual. The sacro-lumbar ligaments may be injured by strain and, if so, may in the process of healing affect the lumbo-sacral cord of the sacral plexus of nerves. The capsular ligaments are strong and do not seem to be affected except in cases of exostosis of the articular process. When such a condition exists, they are thickened at the point of contact with the vertebra above or below.

Muscles.—As in other regions, the muscles will be listed and discussed from a standpoint of function only. The following list includes some muscles that act indirectly on the lumbar region. Gravity plays an important part in all movements of this region.

Latissimus dorsi.—Side-bending; both acting, extension.

Ilio-costalis lumborum.—Side-bending; both acting fix the region.

Longissimus dorsi.—Side-bending.

Spinalis dorsi.—Side-bending; both acting, extension.

Multifidus.—Extension.

Interspinales.—Extension.

Intertransversarii.—Side-bending.

Quadratus lumborum.—Side-bending.

Psoas magnus.—Side-bending; both acting, flexion.

Psoas parvus.—Side-bending; both acting, flexion.

Rectus abdominis.—Flexion.

External oblique.—Side-bending; both acting, flexion.

Internal oblique and transversalis.—Flexion.

Arteries,—The arteries most commonly affected by abnormalities in this region are the lumbar branches of the abdominal aorta. These pass back from the main artery under the fibrous arches of origin of the psoas magnus muscle and give off spinal and muscular branches. They may be affected by pressure of viscera anteriorly or by changes in the lumbar vertebrae, especially at the intervertebral foramina. In cases of Pott's disease, the relation of the abdominal aorta and inferior vena cava must be remembered. These vessels are in direct relation to the bodies of the lumbar vertebrae and are displaced in proportion to the extent of the deformity. Scoliosis affecting the lumbar region will displace the vessels also, but this condition is slower in effect and compensation takes place in most cases noted. The sacra media branch of the aorta may be affected in lesions of the lumbo-sacral articulation, or between the fourth and fifth lumbar.

First Lumbar Segment

VOLUNTARY.—Erector spinae, multifidus, interspinales, intertransversarii, quadratus lumborum, external oblique, internal oblique, transversalis, cremaster.

INVOLUNTARY.—Connected with the lateral chain by grey and white rami, the grey ramus carrying impulses to be distributed over the cutaneous nerves originating from this segment, and the white ramus acting as part of the origin of the thoracolumbar cord, the impulses being carried to the lower half of the body.

SENSORY.—To the skin of the back in the region of the spinous processes of the first and second lumbar, over the crest of the ilium to the anterior gluteal region, the epigastric region of the abdomen, the skin over the inguinal canal and the external genitals.

ARTICULAR.—To the corresponding spinal segment.

Second Lumbar Segment

VOLUNTARY.—Erector spinae, multifidus, interspinales, intertransversarii, quadratus lumborum psoas magnus, psoas parvus, cremaster; and muscles of the inner side of the thigh thru the obturator nerve and of the anterior surface of the thigh thru the anterior crural nerve.

INVOLUNTARY.—Connected to the lateral chain by grey and white rami, the grey rami carrying impulses to be distributed over the cutaneous nerves, originating from this segment, and the white ramus

acting as part of the origin of the thoraco-lumbar cord, the impulses being carried to the lower half of the body.

Sensory.—To the external genitals, the skin of the lateral, anterior and mesial surfaces of the thigh, and inner side of the leg and foot.

Articular.—To the corresponding spinal segment, symphysis pubis, hip- and knee-joints.

Third Lumbar Segment

Voluntary.—Erector spinae, multifidus, interspinales, intertransversarii, quadratus lumborum, ilio-psoas, pectineus, and muscles of the inner side of the thigh thru the obturator nerve and on the anterior surface thru the anterior crural nerve.

Involuntary.—Receives a grey ramus from the lateral chain of ganglia, the impulses to be distributed over the cutaneous nerves originating from this segment; furnishes the last white ramus of origin of the thoraco-lumbar cord, the impulses of which are distributed to the lower half of the body.

Sensory.—To the skin of the lateral, anterior and inner surfaces of the thigh, inner surface of the leg and foot, and to the skin of the back and extending over the crest of the ilium into the gluteal region.

Articular.—To the corresponding spinal articulations, and the hip- and knee-joints.

Fourth Lumbar Segment

Voluntary.—Erector spinae, multifidus, interspinales, intertransversarii; also the muscles of the thigh, leg and foot thru the obturator, anter-

ior crural, superior gluteal, nerve to the quadratus femoris and the great sciatic nerves.

Involuntary.—Receives a grey ramus carrying impulses to be distributed over the cutaneous nerves originating from this segment.

Sensory.—To the anterior and mesial surfaces of the thigh; to the leg and foot thru the great sciatic nerve.

Articular.—To the corresponding spinal articulations and all articulations of the lower extremity.

Fifth Lumbar Segment

Voluntary.—Erector spinae, multifidus, interspinales, intertransversarii; muscles of the lower extremity thru the great sciatic, superior gluteal, inferior gluteal, nerve to the obturator internus and nerve to the quadratus femoris.

Involuntary.—Receives a grey ramus carrying impulses to be distributed over the cutaneous nerves originating from this segment.

Sensory.—To the leg and foot thru the great sciatic nerve.

Articular.—To the corresponding spinal articulation and all articulations of the lower extremity.

Viscera.—The receptaculum chyli lies anterior to the bodies of the first and second lumbar vertebrae and will be affected in disease of the bone. Tuberculosis affecting the lymphatics of the abdomen and carried to the receptaculum chyli may be transmitted to the bodies of the vertebrae. The pancreas crosses the body of the second lumbar. The

duodenum is in relation to the first, second, and third lumbar vertebrae and may receive or transmit disease. Laterally, the bodies are covered by the psoas muscle, but are in close relation to the ureters and pelves of the kidneys. The mesentery of the small intestine is attached to the bodies of the lumbar vertebrae beginning at the second on the left and terminating at the fifth on the right. Except for the anterior surface of the body of the fifth lumbar, the small intestine is separated from the vertebrae by vessels and musculature.

Movement.—The free movements of the lumbar region are affected by the same factors as in other regions. Age decreases movement, and there is a tendency to straighten the curve somewhat. This is due to the changes that take place in the intervertebral discs rather than any effect on the bony structure. Abnormalities, as ankylosis and Pott's disease, may occur at any time, the former being more common in later life and the latter before the thirtieth year. The author has had the opportunity to examine several contortionists and finds that the hypermobility developed in such cases is confined to the articulations of the upper three lumbar and lower two dorsal vertebrae. One case showed a marked "S" curve, the individual stating that the curve was increasing rapidly. Others showed evidence of maldevelopment of the spinous processes in the regions mentioned.

CHAPTER VII.

THE SACRAL AND COCCYGEAL REGIONS

The sacrum and coccyx constitute the distal segments of the spinal column and in the adult represent the fusion of several bony segments into two bones, situated in the midline and suspended between the innominata. The sacrum is roughly pyramidal in shape having an anterior, a posterior and two lateral surfaces, a base and an apex. The base is directed upwards and articulates with the fifth lumbar vertebra, the articulation of which has already been described. The anterior or pelvic surface of the sacrum is concave and is directed downwards and forwards, its widest part being at the base and rapidly becoming narrower as the apex is approached. The posterior surface is convex and rough. In the midline an irregular ridge of bone is present, representing the fused spinous processes of the original five segments. Of these the first is quite well-defined. The second and third seem to blend in most cases, and those of the fourth and fifth are more often absent or too small to be readily recognized. Between the spinous ridge and the overhanging posterior part of the ilium, there is a depression which is filled by a dense mass of muscular tissue and covered by the dense aponeurotic tissue, serving as the

origin of the erector spinae mass. This tissue completely covers the posterior surface of the sacrum except in the midline and makes palpation of any of the deeper bony prominences very difficult. Foramina are found on both the anterior and posterior surfaces which transmit the sacral nerves, arteries and veins. The apex is rather blunt, directed inferiorly, and articulates with the coccyx. The lateral surfaces are broad above, but narrow below and are not in parallel planes, being separated anteriorly more than posteriorly. The lateral surfaces support the articular area which is covered by hyalin cartilage and a synovial membrane. This surface in most cases is semilunar in shape, and if a circle be drawn the center of which is taken at the posterior superior spine of the ilium, the circumference will pass thru the center of the articular surface of the sacrum, the parts being in normal position. Posterior to the articular surface, the lateral margin of the sacrum is rough for the attachment of the posterior sacro-iliac ligaments; and inferior to the articular surface, it is again rough for the attachment of the great and lesser sacro-sciatic ligaments. The gluteus maximus muscle is attached to the lower and the posterior surfaces; and the pyriformis, to the anterior surface between the sacral foramina. At the extreme lower part of the anterior surface, there is a small space for the attachment of the upper fibers of the coccygeus muscle.

The coccyx is the terminal portion of the spinal column and articulates only with the apex of the sacrum. It may be composed of two segments, but is usually a single bone. It represents the fusion of

four coccygeal segments. Attached to it posteriorly are the gluteus maximus and external sphincter ani muscles; and anteriorly, the coccygeus and levator ani. It is freely movable on the sacrum, being connected with it by a loosely woven fibro-cartilage and a continuation of the periosteum.

Some important points must be brought out relative to the innominata, but the reader should realize that the following description of the bones is by no means complete.

The posterior superior spine is found at the posterior extremity of the iliac crest and is an important point to consider in movements of the sacro-iliac articulation. The posterior inferior spine is about one and one-half inches lower and more difficult to palpate, being covered by heavy fascia and muscle fibers. The tuberosity of the ischium may be readily palpated, deep to the inferior margin of the gluteus maximus. The crest and spine of the pubes may in most cases be palpated anteriorly. The anterior superior spine of the ilium is found at the anterior extremity of the crest of the ilium and is easily palpated. The articular surface of the ilium corresponds in shape and size to the articular area of the sacrum. Posterior to this area, the bone is rough for the attachment of the posterior sacro-iliac ligaments, and along the inner margin of the tuberosity, a rough ridge serves as the attachment of the greater sacro-sciatic ligament. The ischial spine, found along the posterior margin of the bone, serves as the attachment of the lesser sacro-sciatic ligament.

The inner border of the body of the pubes is oval in form, the long axis being oblique and directed upwards and forwards. It is rough, being covered by fibro-cartilage and forming with its fellow of the opposite side the symphysis pubis.

That portion of the bone forming the ilio-pectineal line is a heavy ridge, extending from the pubes anteriorly to the center of the articular surface posteriorly and supporting below, and about midway, the acetabulum.

There are three articulations associated with these bony parts: the sacro-iliac, between the sacrum and the ilium; the sacro-coccygeal, between the sacrum and the coccyx, and the symphysis pubis or interpubic, uniting the innominata anteriorly.

The Sacro-iliac Articulation

CLASS.—DIARTHROSIS. SUBDIVISION.—ARTHRODIA.

Early anatomists described this articulation as an immovable joint, and it has been only in the last several years that it has been admitted by all authors that certain forms of movement are normally present in the joint. Dr. A. T. Still was undoubtedly the first to describe the sacro-iliac movement, this being only one of his many discoveries in connection with the mechanics of the spine. Later Goldthwaite described the movement, publishing his findings and thereby gaining for himself in the medical world a name, which properly belongs to Dr. A. T. Still.

The following ligaments are associated with the articulation: anterior sacro-iliac, posterior sacro-iliac, great sacro-sciatic and lesser sacro-sciatic.

The anterior sacro-iliac is found as a thickened extension of the periosteum of the bones, extending across the joint anteriorly. Superiorly it blends with what may be termed a superior sacro-iliac ligament and inferiorly has the same relation. It is not of sufficient strength to serve as a well-defined support of the joint and should with the superior and inferior portions be thought of as a capsular ligament.

The posterior sacro-iliac ligament is divided into two parts, the transverse portion and the

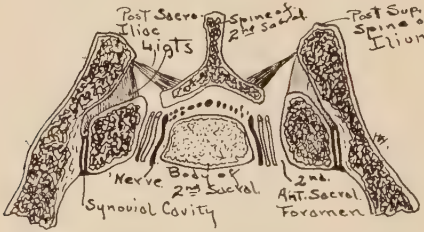


Fig. 52. Drawing taken from a section of the sacro-iliac articulation made through the second sacral spinous process.

oblique portion. The transverse part of this ligament consists of a dense mass of short fibers deeply placed, extending from the mesial surface of the ilium adjacent to the posterior superior spine and extending across to the posterior surface of the sacrum between and lateral to the foramina. The oblique portion of the ligament is longer and more superficially placed and may be better defined as a single ligament. It extends from the posterior superior spine of the ilium to the posterior surface of the sacrum, being attached to tubercles representing the remnants of articular processes.

The great sacro-sciatic ligament is attached superiorly to the posterior margin of the ilium between the posterior spines, to the posterior surface and lateral margin of the lower part of the sacrum, and to the lateral margin of the upper part of the coccyx. From this attachment, the fibers pass downward and forward to the inner border of the tuberosity of the ischium, where they are securely fixed. Some of the fibers are continuous with the tendon of origin of

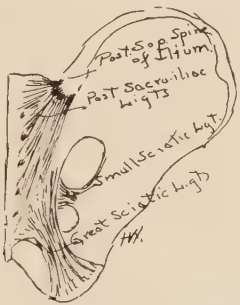


Fig. 53. The posterior ligaments of the sacro-iliac articulation.

the biceps femoris muscle, indicating that contraction of this muscle may have some effect upon the articulation.

The lesser sacro-sciatic ligament is attached to the lateral border of the sacrum and coccyx, anterior to the fibers of the great sacro-sciatic ligament. Passing outward and forward, the ligament is attached to the inner surface of the spine of the ischium.

A well-defined plate of cartilage is attached to each bone at the articular surfaces which are separated by a synovial membrane. In the laboratory, considerable variation in the extent of the synovial

membrane and the form of the intervening cartilage is found in the joint. In most of the older cases, the synovial cavity cannot be demonstrated, and there seems to be a single cartilaginous plate which, in the separation of the bony parts, may adhere to one or the other.

The arterial supply is from the superior gluteal and lateral sacral arteries; the nerve supply, from the superior gluteal and posterior primary divisions of the upper two or three sacral nerves.

The Sacro-coccygeal Articulation

CLASS.—SYNCHONDROSIS

The ligaments binding the coccyx and sacrum together are the intervertebral fibrocartilage, the anterior and posterior sacro-coccygeal ligaments. The fibrocartilage is slightly different from other intervertebral discs in that it is very loosely woven and allows of great freedom of movement. Its anterior and posterior margins are blended with the anterior and posterior ligaments and laterally with the adjacent fibers of the sacro-sciatic ligaments.

The anterior sacro-coccygeal ligament is continuous with the anterior common ligament of the spine and shows a marked thickening, passing over the articulation. The posterior sacro-coccygeal ligament is a blending of the supraspinous and posterior common ligaments of the spine and is often divided into deep and superficial portions.

The arterial supply is mainly from the sacra media artery; and the nerve supply, from the fifth sacral and coccygeal nerves.

The Symphysis Pubis

CLASS.—AMPHIARTHRODIAL

The pubic bones which form this articulation are connected by an interpubic cartilage and a well-defined capsular ligament, parts of which are designated as superior, inferior, anterior and posterior.

The interpubic fibrocartilage differs in individuals. Typically it consists of a layer of hyalin cartilage in relation to each bone, the two being separated by a cavity, varying in size from a very narrow slit to one extending to the margins of the

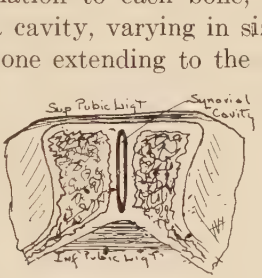


FIG. 54. A section through the symphysis pubis.

cartilage. This is not a true synovial cavity, but seems to be merely a separating of the two parts of the cartilage. Anteriorly the bones are connected by a mass of thick fibers which blend with the interpubic disc deeply, and superficially with the aponeurosis of the external oblique muscle of the anterior abdominal wall. The posterior ligament is thin and consists of a few scattered fibers which blend with the disc. The inferior ligament is much better defined, passing between the pubic bones. Its fibers are well-defined and strong, blending with the capsular ligament above, and below being separated from the triangular ligament by the dorsal

vein of the penis. Laterally, it extends for a short distance onto the descending ramus of the pubis.

Movements

A great diversity of opinion exists about the degree and form of movement in the articulations of the normal pelvis; in fact, such a difference of opinion is found that it is difficult to get any two who have given the matter serious thought to agree in all their ideas. The following facts have been demonstrated in the laboratory and while they conform to the general opinion that movement is present, yet they prove beyond a doubt that some who are often referred to as authorities, are not correct in their ideas about these articulations.

The following statements must be kept in mind at all times in dealing with the pelvic articulations:

Bilateral movement at the sacro-iliac articulations in the sagittal plane is not accompanied by movement at the symphysis pubis.

Unilateral sacro-iliac movement involves the articulation at the symphysis pubis.

Bilateral movement at the symphysis pubis of any form involves the sacro-iliac articulations.

The sacro-coccygeal articulation is independent of either the sacro-iliac or the interpubic articulations.

Extension.—Extension of the sacrum is present as a normal movement and, as described earlier in connection with other regions of the spine, is the result of backward-bending. In this movement an unlocking of the sacro-iliac articulation takes place so that the sacrum is freely movable. When

this takes place the following points are noted: the promontory of the sacrum is separated from the symphysis pubis; the apex of the sacrum and the coccyx are approximated to the symphysis pubis; the anterior sacro-iliac ligament is tensed; the greater and lesser sacro-sciatic ligaments are relaxed; the pelvic inlet is increased and the outlet decreased.

Flexion.—Flexion of the sacrum as an initial movement does not exist normally. It occurs as a secondary movement when the sacrum returns from a

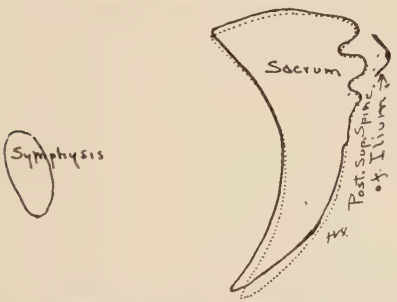


FIG. 55. The dotted lines show the sacrum in its normal position; the dark lines, in extension. Movement from the position of extension to that of normal simulates flexion, but is not true flexion according to the author's definition.

position of extension to the normal. This movement is centered around an axis drawn between the posterior superior spines of the ilum and is bilateral, each articulation taking an equal part and passing through the same form of movement. The greatest amount of movement of any part of the sacrum occurs at its apex, it being the most distant point from the center of movement. The coccyx is carried with the sacrum in this movement, the sacro-coccygeal articulation not necessarily being involved.

This is best demonstrated by putting the spine first in a position of extension, inasmuch as we find that, in the upright position either sitting or standing, the articulation is locked and continues to be so in forward-bending of no matter what degree. In returning to the normal position from one of extension, the promontory of the sacrum approaches the symphysis pubis, decreasing the pelvic inlet. The apex of the sacrum and coccyx are separated from the symphysis pubis, increasing the pelvic outlet. Relaxation of the anterior sacro-iliac ligaments occurs with greatly increased tension upon the greater and lesser sacro-sciatic ligaments. There will be increased tension also on the entire group of perineal muscles. In either of these movements, flexion or extension, there is no change in the length of the limb, and no other pelvic articulations are involved.

Rotation.—By forcibly rotating the sacrum on the fifth lumbar, a movement occurs which involves all of the articulations of the pelvis, is similar to rotary movements of the spine, and is present only at a point midway between the limits of normal position and hyperextension. On the side to which the sacrum is rotated, that is, on the side to which the body of the sacrum is rotated, there will be extension of the innominate at the sacro-iliac articulation, an upward and forward gliding at the symphysis pubis, following the long axis of the joint, and the tensing of the sacro-sciatic ligaments on that side, resulting in slight deflection of the coccyx toward the same side. On the side away from which the rotation occurs, or on the side to which

the spinous ridge of the sacrum is approximated, there will be flexion of the innominate at the sacro-iliac articulation, a downward and backward gliding at the symphysis pubis in the direction of its long axis and relaxation of the sacro-sciatic ligaments, the coccyx being deflected away from that side slightly. There will be a slight change in the length of the limbs, not over one-quarter of an inch, the limb on the side to which the sacrum is rotated being the shorter. This movement, if all pelvic articulations are normal, accompanies the act of walking to a slight extent.

The interpubic articulation or symphysis pubis normally is freely movable. The movements may be classified as rocking and gliding, the latter occurring in two axes. In the rocking movement, there will be separation of the tuberosities of the ischii, tension on the sacro-sciatic ligaments, and flexion at the sacro-iliac articulations. An equal shortening of both limbs occurs. In the gliding movements in either axis, the innominate of the opposite side should be considered fixed in relation to the sacrum. This movement, if through the long axis of the joint, will result in an upward and forward, or downward and backward movement at the symphysis. The upward and forward gliding is accompanied by unilateral extension of the innominate at the sacro-iliac articulation, with slight separation of the tuberosities of the ischii. The downward and backward gliding results in unilateral flexion of the innominate at the sacro-iliac articulation, with slight approximation of the tuberosities of the ischii. Gliding may occur also in the line of the

short axis of the articulation. This movement, occurring upward and backward, is accompanied by extension of the innominate at the sacro-iliac articulation on the same side or, if the gliding is downward and forward, will be accompanied by flexion of the innominate at the sacro-iliac on the same side. With the sacro-iliac articulations unlocked, these gliding movements occurring bilaterally in opposite directions result in rotation of the sacrum or in the condition many times referred to as "twisted pelvis."

The movement at the sacro-coccygeal articulation is mainly flexion and extension and is free, having a range of about forty-five degrees. A small degree of lateral movement is possible and occurs in connection with rotation of the sacrum.

Diagnosis

There are as many methods of diagnosing sacro-iliac movements as there are ideas about them, and consequently we find ourselves often tangled in a mass of intricate and specially made instruments, purporting to tell the story accurately. Before making any attempt at diagnosis, we must first discover the palpable structures of the pelvis that change their position with movement. Posteriorly the spinous ridge of the sacrum may be palpated and may be followed inferiorly to the sacro-coccygeal articulation. The posterior superior spines of the ilium are easily located. Beneath the lower margin of the gluteus maximus, the great sacro-sciatic ligament may be located, but it is much better, if accurate diagnosis is desired, to palpate this ligament and also the lesser sacro-

sciatic per-rectum in the male or thru the vaginal wall in the female. The tuberosities of the ischii may always be located mesial to the margin of the gluteus maximus. Anteriorly the pubic crest may be palpated in most cases, if not the pubic crest, the spine of the pubes may serve. The anterior superior spine of the ilium may always be easily located.

In movement of the sacrum from extension to its normal position, the following diagnostic points should be noted: The coccyx and apex of the sacrum will be prominent. The sacro-sciatic ligaments will be tense. No changes are noted at the spines of the ilia or at the symphysis pubis.

In extension of the sacrum, accompanied by compensatory flexion at the sacro-lumbar articulation, the first sacral spinous process and the spinous process of the fifth lumbar will be prominent and there will be relaxation of the sacro-sciatic ligaments. No changes are noted at the spines of the ilia or at the symphysis pubis.

Unilateral flexion of the innominate at the sacro-iliac articulation is the same as the downward and backward gliding described at the symphysis pubis, and in this movement the crest of the pubes will be low on the affected side with slight lengthening of the limb and lax sacro-sciatic ligaments. Unilateral extension of the ilium at the sacro-iliac articulation results in a high pubic crest, slight shortening of the limb and tense sacro-sciatic ligaments on the same side.

In the bilateral gliding movement at the symphysis pubis, there will be a prominent posterior superior iliac spine, slightly high iliac crest, shortening

of the limb and high pubic crest on one side with depressed posterior superior iliac spine, low crest of the ilium, slight lengthening of the limb and low pubic crest. In this bilateral movement, there is very little change in the tensity of the sacro-sciatic ligaments on account of the slight amount of rotation of the sacrum.

Summarizing the above, the following points should be kept in mind. The posterior superior iliac spines are of diagnostic value only in the bilateral gliding movement of the symphysis or "twisted pelvis." The sacro-sciatic ligaments may be lax or tense and are of great value in indicating movement. The slight variation in the length of the limbs and the condition at the pubic crest should be noted in all movements of the symphysis pubis.

Structures Affected

Bone.—In this region as in all others slight variations in the form of the bones occur and are often misleading. It is for this reason that we would urge a more intimate study of bones and their many abnormalities. The sacrum varies in the male and female, being slightly broader in the female and not curved as sharply anteriorly. The male sacrum possesses a more even curve while that of the female is somewhat flattened in its upper part. The spinous ridge is very irregular, in some cases being quite prominent and in others difficult to palpate. The first, second, and third spinous processes may be palpated in some cases, but usually only the first may be distinguished as a separate structure. In very thin individuals the promontory of the sa-

crum may be palpated through the anterior abdominal wall, and cases are on record where it has been taken for a bony tumor In such cases it may be palpated below the bifurcation of the abdominal aorta, which is located by its pulsations.

The coccyx is subject to displacement and to variation in position, but may be easily palpated per rectum between the palpating finger in the canal and the thumb on the outer surface. It is often found to consist of two distinct parts and, when such cases are found, must not be mistaken for fracture. On account of its position it is easily injured in falls astride fences or the like.

Laboratory findings indicate a great variation in the spines of the ilium. They may be large on one side and quite small and pointed on the other. This is especially true of the anterior superior spine of the ilium which is influenced more by the attachment of muscles. The pubic region is found to be the most symmetrical, seldom showing any marked abnormality. The pelvic bones as a whole should be noted carefully in all cases as they form the foundation of the spine and must be in proper alignment before normal regions may be expected above. Congenital or acquired deformities are not uncommon. Disease such as rickets, osteomalacia, and tuberculosis may have a marked effect upon the entire structure. Exostosis is found associated with the sacro-iliac articulation usually beginning about the fiftieth year and will be noted first at the upper part of the articulation as an extension from the alae of the sacrum. The pelvic bones are subject to fracture the same as other bones of the body,

but, on account of the prominence of certain parts, the articulations are not usually involved directly.

Ligaments.—Great strain is always present on the posterior sacro-iliac ligaments and these are seen to be most commonly affected. It is not unusual to find the ligaments on one side much more dense and heavily fibered than on the other. Also they are more often found ossified, evidently attempting to limit or obliterate the movement in the articulation. The sacro-sciatic ligaments are subject to great strain also and on account of the exposed position the great sacro-sciatic is often injured. Several cases have been found where it has apparently been ruptured. This would materially weaken the sacro-iliac articulation, allowing a greater degree of flexion. Contractured fasciculi of the erector spinae mass have been taken for thickened ligaments posteriorly. The direction of the ligaments should be noted and comparison made with the fibers of the muscle. The triangular ligament, which is found in the pubic arch, and its associated structures may be affected by abnormalities of the symphysis pubis.

Muscles.—Muscles do not play an important part in the movements of the pelvis. Gravity and indirect leverage produce most of the movement, yet a few muscles are important as supports in certain movements and may when contractured result in fixation of the articulations.

Psoas magnus and parvus.—Flexors, either. unilateral or bilateral, if the lumbar region is fixed

Pyriformis.—Extensor, either bilateral or unilateral.

COCCYGEUS.—Flexor of the coccyx, extensor of the sacrum.

GLUTEUS MAXIMUS.—Extensor, either unilateral or bilateral.

The perineal group must act together and if contractured will cause extension of the sacrum, if relaxed will tend to cause extension of the ilia.

If the limbs be fixed apart and the adductor muscles contractured, there will be a rocking movement established at the symphysis. This should be remembered in the various movements involving the use of the thigh in abduction.

Arteries.—The ilio-lumbar, lateral sacral and common iliac arteries pass over the sacro-iliac articulation and may be involved in abnormalities of the joint. The internal pudic, sciatic and gluteal arteries lie in intimate relation to the sacro-sciatic ligaments and may be affected by pressure in that region.

Veins.—Veins corresponding to the above mentioned arteries may be affected with the arteries, resulting in congestion. In addition, the position of the deep dorsal vein of the penis or clitoris should be noted as it passes beneath the symphysis pubis to empty into the vesical plexus and is certain to be disturbed in abnormalities of the articulation.

Nerves.—The most commonly affected nerve strands in this region are the lumbo-sacral cord of the sacral plexus and the obturator. Contractured tissues at the sacro-iliac articulation will increase the tension on these nerves on account of the compensating extension in the lumbar region. Six segments of the spinal cord make their exit in this

region, any one of which may be affected directly or indirectly by pelvic abnormalities.

First Sacral Segment

VOLUNTARY.—Erector spinae, multifidus, gluteus maximus, medius and minimus, tensor fascia lata, quadratus femoris, superior and inferior gemelli, obturator internus and pyriformis; the muscles on the back of the thigh and all of the leg and foot thru the great sciatic nerve.

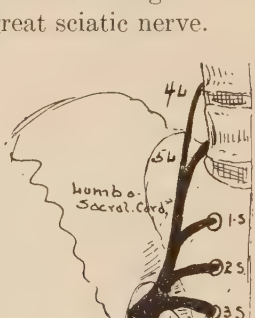


FIG. 56. The relation of the lumbo-sacral cord of the sacral plexus to the sacro-iliac articulation.

INVOLUNTARY.—Receives a grey ramus from the lateral chain, carrying impulses to be distributed over the cutaneous branches originating from this segment.

SENSORY.—Posterior sacral region, back of thigh, gluteal and perineal regions; all of the skin of the leg and foot except the inner surface.

ARTICULAR.—To the sacro-iliac and all articulations of the lower extremity.

Second Sacral Segment

VOLUNTARY.—Erector spinae, multifidus, gluteus maximus, obturator internus, superior gemellus, pyriformis, transversus perinei, ischio-cavernosus, bulbo-cavernosus, and sphincter vaginae; the muscles on the back of the thigh and all of the leg and foot thru the great sciatic nerve.

INVOLUNTARY.—Receives a grey ramus from the lateral chain, carrying impulses to be distributed over the cutaneous branches originating from this segment; gives off a white ramus passing directly into the formation of the pelvic nerve to the pelvic plexus.

SENSORY.—Posterior surface of sacrum, back of thigh, gluteal and perineal regions; external genitals; all the skin of the leg and foot except the inner surface.

ARTICULAR.—To the sacro-iliac articulation and all joints of the lower extremity.

Third Sacral Segment

VOLUNTARY,—Erector spinae, multifidus, transversus perinei, ischio-cavernosus, bulbo-cavernosus, sphincter vaginae, levator ani and coccygeus; muscles on the back of the thigh and all the muscles of the leg and foot thru the great sciatic nerve.

INVOLUNTARY.—Receives a grey ramus from the lateral chain, carrying impulses to be distributed to the cutaneous branches originating from this segment; gives off a white ramus passing directly into the formation of the pelvic nerve to the pelvic plexus.

Sensory.—Posterior surface of sacrum, thigh, gluteal and perineal regions; external genitals; all of leg and foot except inner surface.

Articular.—To the sacro-iliac and all articulations of the lower extremity.

Fourth Sacral Segment

Voluntary.—Coccygeus, levator ani, external sphincter ani, transversus perinei, ischio-cavernosus bulbo-cavernosus and sphincter vaginae.

Involuntary.—Receives a grey ramus from the lateral chain, carrying impulses to be distributed over the cutaneous nerves originating from this segment; gives off a white ramus passing directly into the formation of the pelvic nerve to the pelvic plexus.

Sensory.—Perineal region and external genitals.

Articular.—Symphysis pubis.

Fifth Sacral and Coccygeal Segments.

These two small nerves join to form the coccygeal plexus which is distributed to the skin over the coccyx. They receive grey rami from the lateral chain and the ganglion impar. Pain in the coccygeal region is often due to irritation to this small plexus through coccygeal lesions.

Viscera.—The viscera in the pelvic region are affected by gross abnormalities more than by the lesser or more common ones occurring in the region. It should be remembered that abnormalities of the viscera such as tumors, cysts, etc., are often the cause of disturbance in the bony pelvis and may

result in compensation in other parts of the spine. The coccyx, on account of its position, may directly impinge upon the anal canal.

Movements.—Age and sex are important factors in the noted variations in pelvic movement. In the young all movements are free and can be easily recognized. As age advances, these movements are reduced until we find in the laboratory that practically every case over fifty years has complete loss of movement or it is reduced to a minimum. This ankylosis begins at the sacro-iliac articulation and is usually not developed the same on both sides, indicating that there has been some form of abnormal disturbance there, initiating the condition earlier on one side than on the other. This unilateral condition has been found as early as the twenty-fifth year in some cases and plainly shows the results of irritation to the joint. With a loss of movement at the sacro-iliac articulation, there will be a gradual atrophy of the cartilage at the symphysis pubis and ossification will take place. Unless due to direct injury the sacro-coccygeal articulation is the last to ankylose and even in very old cases shows some degree of movement.

All movements are especially free in the young female, and, during the physiological process of pregnancy, the ligaments undergo further relaxation. The increased width of the sacrum allows a slight increase in the movements and they are performed with greater ease. The tendency to lesion in such cases is due to the increased superimposed weight, a similar condition or susceptibility being found in cases of obesity. Faulty posture in chil-

dren is a great factor in the development of pelvic abnormalities. This condition affects the bones before they are fully formed and the effects are carried thru life. More attention should be given to the pelvis and its articulations, for it is the foundation for the entire spine.

CHAPTER VIII.

THE CRANIAL NERVES

Olfactory Nerve (First Cranial).—This is a nerve of special sense transmitting impulses of smell from the olfactorymembrane of the nasal fossa to brain; it consists of from 15 to 20 filaments which pass through the cribriform plate of the ethmoid bone and terminate in the olfactory bulb of the brain.

Optic Nerve (Second Cranial).—This is a nerve of special sense carrying impulses of sight from the retina to the brain. The optic nerve proper begins at the postero-mesial surface of the eyeball, passes posteriorly from it thru the optic foramen, carries impulses from both halves of the retina of respective eye. The optic chiasm in the cranial cavity is the result of decussation of some of the fibers of this nerve. Nerve fibers from the nasal side of each retina decussate to the opposite side and are carried back to the brain by the optic tract. Lesion of the optic nerve causes total blindness of one eye. Lesion of the optic chiasm may cause (1) total blindness of both eyes, (2) heteronymous hemianopsia. Lesions of the optic tract may cause either right or left homonymous hemianopsia. The fibers of the nerve may be traced centrally to the lateral geniculate body, optic thalamus, and to the superior corpus quadrigeminum.

Oculo-motor Nerve (Third Cranial).—This nerve is motor to most of the muscles of the orbit; it emerges from the oculo-motor sulcus of the mid-brain, pierces the dura mater in the middle cranial fossa, traverses the lateral wall of the cavernous sinus, enters the orbit through sphenoidal fissure, divides into branches supplying levator palpebrarum, superior

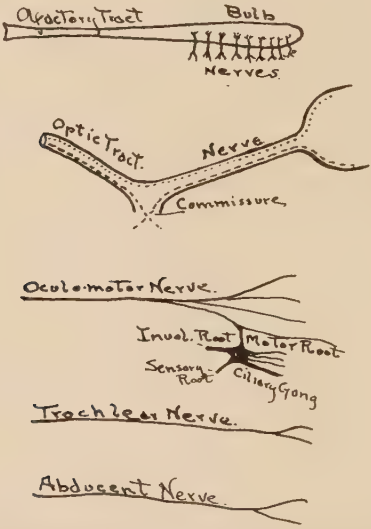


FIG. 57. The first, second, third, fourth and sixth cranial nerves.

rectus, internal rectus, inferior rectus, and inferior oblique, and receives secretory and involuntary motor filaments from cavernous plexus of the involuntary nervous system, and sensory ones from the ophthalmic division of the trigeminal nerve. A lesion along the path of this nerve will affect movements of the eyeball and the upper eye lid; lesions

in the cervical or dorsal areas of the spine may disturb involuntary impulses to the eye.

Trochlear Nerve (Fourth Cranial).—This nerve is motor to the superior oblique muscle of the eyeball, emerges through the anterior medullary velum, passes anteriorly in the lateral walls of the cavernoos sinus below the oculo-motor nerve, passes through the sphenoidal fissure into the orbit, supplies only the one muscle mentioned, and receives filaments from the cavernous plexus of the involuntary nervous system, and sensory from the ophthalmic division of the trigeminal nerve. Lesions of this nerve interfere with movements of the eyeball.

Trigeminal Nerve (Fifth Cranial).—The function of this nerve is two-fold: it is sensory to the face, forehead, nose, mouth, anterior portion of the tongue, and the teeth; motor for the muscles of mastication. The motor root is associated with the mandibular division only, the three sensory divisions are associated with the Gasserian ganglion in the cranial cavity.

The ophthalmic division passes forward in the lateral wall of the cavernous sinus, enters the orbit through the sphenoidal fissure and gives off a recurrent branch to supply the adjacent dura mater. It divides into three branches, as follows: (1) lacrimal which supplies the lacrimal gland, the conjunctiva and the skin of the upper eyelid; (2) frontal which leaves the orbit through the supra-orbital notch and supplies the skin of the forehead and the scalp to the vertex; (3) nasal, giving off sensory roots to the ciliary ganglion, branches to the eyeball, the ethmoidal and sphenoidal

cells, the skin at the inner canthus of the eye and the adjacent side of the nose, and the anterior ethmoidal nerve which passes into the nasal fossa, supplying the anterior part of the septum and the adjacent lateral wall and the skin of the lower half of the nose.

The maxillary division leaves the cranial cavity through the foramen rotundum, enters first the spheno-maxillary fossa, then the orbit through the

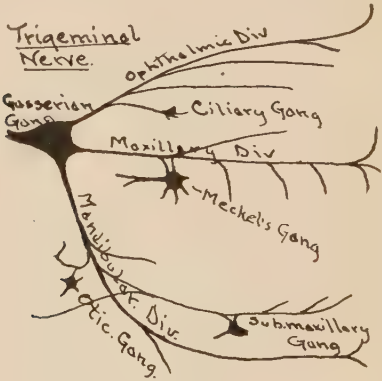


Fig. 58. The fifth cranial nerve.

spheno-maxillary fissure, becomes the infra-orbital and as such traverses the infra-orbital canal and foramen and terminates on the face. It supplies the dura mater by a recurrent branch, sends sensory roots to the spheno-palatine ganglion, gives off sensory branches to the malar and anterior temporal regions and the upper teeth. The terminal branches on the face supply the lower eyelid, the side of the nose and the upper lip.

The mandibular division leaves the cranial fossa through the foramen ovale to enter the pterygoid region. It is sensory to dura mater by a recurrent branch, motor to the internal and external pterygoids, masseter, temporal (muscles of mastication), the mylo-hyoid and the anterior belly of the digastric; also sensory to the temporal region, the cheek, the external ear, and the skin over the mandible. It further supplies the lower teeth and the floor of the mouth and receives the chorda tympani nerve from the facial, carrying gustatory impulses to the tongue; sends articular branches to the temporo-maxillary articulation and is associated with the otic and submaxillary ganglia, giving off sensory roots. Lesions may be of one division or of the entire nerve, but are mainly of a sensory nature.

Abducens Nerve (Sixth Cranial).—This nerve emerges from the lower border of the pons, passes along the lateral wall of the cavernous sinus, enters the orbit through the sphenoidal fissure, and supplies the external rectus muscle. It receives filaments from the cavernous plexus of the involuntary nervous system and sensory ones from the ophthalmic division of the trigeminal nerve. Lesions of this nerve will affect the movement of the eyeball.

Facial Nerve (Seventh Cranial).—It emerges at the lower border of the pons, leaves the cranial cavity by way of the internal auditory canal, at the termination of which it enters the facial canal, passes posterior to the middle ear cavity, making its exit from the temporal bone through the stylo-mastoid foramen, turns forward lateral to the styloid process, and enters the parotid gland, break-

ing up into its terminal branches. It supplies the motor root of the spheno-palatine ganglion, assists in the formation of the tympanic plexus, supplies the stapedius muscle, gives off the chorda tympani nerve which later unites with the mandibular division of the trigeminal nerve and becomes gustatory to the tongue. It also supplies voluntary motor impulses to the muscles of the face, ear and scalp, and communicates with the oculo-motor, vagus and hypoglossal nerves. Lesions of this nerve result mainly in paralysis of the facial muscles.

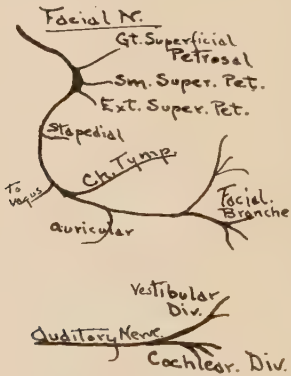


FIG. 59. The seventh and eighth cranial nerves.

Auditory Nerve (Eighth Cranial).—The eighth nerve is a nerve of special sense, controlling hearing, equilibrium, and muscle sense. It leaves the cranial cavity, entering the internal auditory canal. The cochlear division passes to the base of the modiolus or cochlea and terminates in the organ of Corti, while the vestibular division passes to the macula acoustica

of the utricule, saccule, and semi-circular canals. Lesions of this nerve result in deafness or loss of equilibrium.

Glosso-pharyngeal Nerve (Ninth Cranial).—This nerve leaves the cranial cavity through the jugular foramen. The petrous ganglion of this nerve communicates with the superior cervical ganglion of the involuntary system and with the vagus. This nerve assists in the formation of the tympanic plexus, supplies one muscle, the stylo-pharyngeus, gives off branches that are sensory to the pharynx and both sensory and gustatory to the posterior portion of the tongue.

Vagus Nerve (Pneumogastric or Tenth Cranial).—The function of this nerve is three-fold: sensory, voluntary and involuntary motor. This nerve also leaves the cranial cavity through the jugular foramen. It supplies the dura mater with sensory branches in the posterior cranial fossa. It is sensory to the external auditory canal; communicates with the superior cervical ganglion of the involuntary system with the first and second cervical nerves, and the hypoglossal; supplies both sensory and motor branches to the pharynx, larynx, oesophagus; inhibitor to the heart; sensory to the pericardium; motor to the muscles of the bronchial tubes in the lung; motor to the stomach, small intestine and gall bladder; inhibitor to the cardiac end of the stomach, the pyloric valve and the ileocaecal valve; secretory throughout its distribution. The vagus nerve is the cephalic part of the involuntary nervous system and will be discussed in greater detail under that head.

Spinal Accessory Nerve (Eleventh Cranial).—This nerve leaves the cranial cavity through the jugular foramen and passes laterally, receiving communications from the second, third and fourth cervical segments and supplies the sterno-mastoid and trapezius muscles. Lesions affecting this nerve or its accessory branches result in wry neck or torticollis.

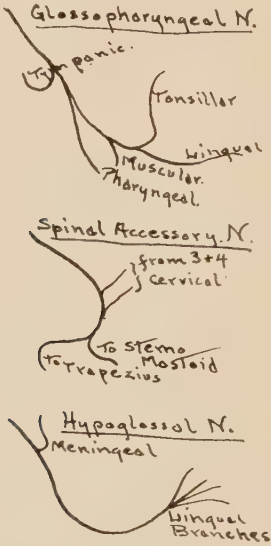


Fig. 60. The ninth, eleventh and twelfth cranial nerves.

Hypoglossal Nerve (Twelfth Cranial).—This nerve leaves the cranial cavity through the anterior condyloid foramen, passes into the neck where it supplies the genio-hyoid, stylo-glossus, hyo-glossus, genio-glossus, and the intrinsic muscles of the tongue. It communicates with the superior cervical ganglion of the involuntary nervous system and with the vagus.

CHAPTER IX.

THE SPINAL NERVES

Before taking up the spinal nerves, it is well to make a few general statements concerning them. A typical spinal nerve has its origin by two roots, from the spinal cord. The anterior root contains motor fibers, being in most cases of the voluntary type, but, in some regions, of the involuntary type also. The posterior root is comprised of fibers carrying sensory impulses that have been gathered from all structures supporting sensation, these for the most part being from the skin or mucous membranes. These two roots are joined laterally to form a mixed spinal nerve which is divided at the intervertebral foramen into anterior primary and posterior primary divisions, each carrying impulses of all kinds. To most of the posterior primary divisions we can apply a rule that will dispose of their distribution, but the anterior primary divisions are grouped above and below the dorsal region into complicated plexuses, each of which must be described in detail.

Altogether there are 31 spinal nerves. These are divided into eight cervical, twelve dorsal or thoracic, five lumbar, five sacral and one coccygeal. Each cervical nerve is found above the vertebra for which

it is named, except the eighth, which is between the seventh cervical and the first dorsal vertebrae. In the dorsal and other regions below, the nerve emerges below the vertebra for which it is named. It is important to remember this fact, especially as it applies to the location of a lesion between any two vertebrae. For instance, a lesion between the fourth and fifth cervical vertebrae may affect the *fifth* cervical nerve, while a lesion between the fourth and fifth lumbar vertebrae would affect the *fourth* lumbar nerve. Associated with each spinal nerve in the intervertebral foramen there is a vein and an artery, the vein assisting in the drainage of the adjacent segment of the cord, and the artery giving it its blood supply.

The Posterior Primary Divisions

The upper three only of this series of nerves are named. The first cervical is called the sub-occipital nerve and is motor to the sub-occipital group of muscles. The posterior primary division of the second cervical is the great occipital nerve and is sensory to the back of the scalp, extending as far as the vertex and there inosculating with the frontal branch of the ophthalmic division of the trigeminal nerve. The third cervical is called the occipitalis tertius and conforms more to the typical arrangement of the posterior primary divisions. Its external branch is motor to the deep muscles at the back of the neck, and its internal branch is sensory, but extends to the scalp in the region of the external occipital protuberance. Beginning with the fourth cervical and on down to and

including the sixth dorsal, these nerves divide into an external branch, which supplies the deeper muscles of the back, and an internal branch, which passes to the skin of the back. Beginning with the seventh dorsal segment and down to the last sacral nerve, the internal branch is motor to the deeper muscles, and the external branch supplies the skin. The cutaneous distribution in each case is from one to two segments lower than the origin of the nerve. The anterior primary divisions are arranged in plexuses in the cervical, lumbar and sacral regions of the spine, but not in the dorsal region. The first four cervical nerves form the cervical plexus. The last four cervical and the greater part of the first dorsal nerves form the brachial plexus. The greater part of the twelfth dorsal, the first three and part of the fourth lumbar nerve form the lumbar plexus. Part of the fourth, all of the fifth lumbar, all of the first and part of the second and third sacral nerves form the sacral plexus. Part of the second and third and all of the fourth sacral nerves form the pudendal plexus. The last sacral and the coccygeal segments form the coccygeal plexus.

The Cervical Plexus

For convenience and brevity this plexus will be divided into three parts, (1) cutaneous branches, (2) communicating branches, (3) muscular branches. Of the cutaneous we have the following: small occipital, from second and third segments, supplying the postero-lateral part of the scalp; great auricular, from the second and third, supplying the posterior surface of ear and adjacent part of scalp and skin

over angle of mandible; transverse cervical, supplying the antero-lateral surface of neck; descending cutaneous, from the third and fourth, dividing into (a) sternal, (b) clavicular, and (c) acromial branches. The sternal branch supplies the skin over the upper part of the sternum and the sterno-clavicular articulation; the clavicular branch passes over the mid portion of the clavicle to the upper part of pectoral region; the acromial branch passes to the region of the acromion process of the scapula and supplies the acromio-clavicular articulation. One of the communicating branches is, the descendens hypoglossi from the first and second, joining with the descendens cervicalis from the second and third, forming the ansa hypoglossi. Each of the segments communicates with the superior cervical ganglion of the involuntary nervous system by means of a grey ramus. Communicating branches from the first and second pass to the vagus, and from the second, third and fourth to the spinal accessory. Motor nerves are given off to the scaleni from the second, third and fourth; to the anterior recti from the first, second, third and fourth; to the infrahyoid group from the first, second and third thru the ansa hypoglossi; the longus colli receives branches from the third and fourth; the levator angulae scapulae from third and fourth; and the phrenic nerve which supplies the diaphragm originates from the third, fourth and fifth segments.

As a summary, the Cervical Plexus can be arranged as follows:—

Cutaneous Branches (4)

Small occipital,

Great auricular,
Transverse cervical,
Descending cutaneous with its three divisions, sternal, clavicular and acromial.

Communicating Branches (5)

Superior cervical ganglion of the involuntary system.
Vagus,
Spinal accessory,
Descendens hypoglossi
Descendens cervicalis.

Muscular or Motor Branches (6)

Scaleni,
Infra-hyoid,
Anterior recti,
Longus colli,
Levator angulae scapulae,
Diaphragm.

The Brachial Plexus

The brachial plexus is found, first in the lower part of the neck and behind the clavicle; it then passes into the axillary space, where the terminal branches are found. It is formed from the anterior primary divisions of the lower four cervical nerves and the greater part of the first dorsal nerve. These five segments are first arranged to form three trunks: the fifth and sixth segments join to form the upper trunk; the seventh segment alone forms the middle trunk; the eighth cervical and first dorsal segments join to form the lower trunk. Following their formation, each divides into anterior and posterior secondary divisions. The anterior secondary divisions

of the upper and middle trunks join to form the outer cord. The anterior secondary division of the lower trunk forms the inner cord. A branch from the inner cord and one from the outer cord join to form the anterior cord. The posterior secondary divisions from all three trunks join to form the posterior cord. These four cords are named for their relation to the axillary artery. Named nerves are given off from various parts of this foundation of the brachial plexus.

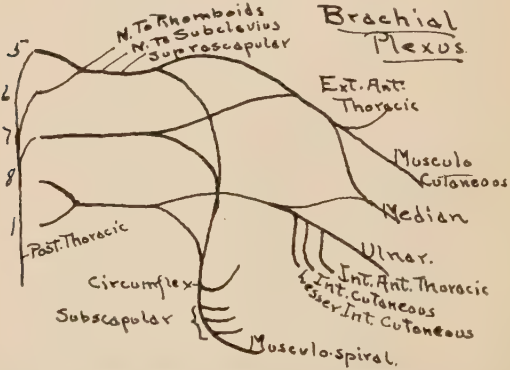


FIG. 61. Diagrammatic representation of the main branches of the brachial plexus.

The dorsalis scapulae nerve, or nerve to the rhomboids, is given off from the upper trunk, but originates from the fifth cervical segment. It is motor to the levator angulae scapulae, rhomboideus major and minor.

The nerve to the subclavius is from the upper trunk and originates from the fifth and sixth segments.

The suprascapular nerve is given off from the upper trunk and supplies with motor impulses the supraspinatus and infraspinatus. It originates from the fifth and sixth segments.

The external anterior thoracic nerve is from the outer cord. It originates from the fifth, sixth and seventh cervical segments and supplies the upper part of the pectoralis major.

The outer cord is continued as the musculo-cutaneous nerve and is motor in the arm and cutaneous in the forearm. It supplies in the arm the coraco-brachialis, biceps and brachialis anticus, then passes to the outer side of the elbow joint and is cutaneous to the anterior half and posterior third of the forearm on the radial side. Its origin is from the 5th, 6th, and 7th cervical segments.

The anterior cord as such gives off no branches, but is continued as the median nerve. It passes thru the arm without giving off any branches, but its relation to the brachial artery should be noted. At first, it is found anterior to this artery, then as it approaches the elbow, it is found internal to the artery, and passes over the anterior surface of the elbow joint, continuing in the same relation. In the forearm, the nerve passes deeply and gives off the anterior interosseous nerve which, with the median nerve, supplies six and one-half muscles on the anterior surface of the forearm. The main nerve trunk then passes into the hand where it supplies four and one-half muscles and is cutaneous to the palmar surface of the hand on the radial side, extending to the ulnar side as far as one-half of the

ring finger. The median nerve originates from the 6th, 7th and 8th cervical and 1st dorsal segments.

The lesser internal cutaneous nerve is given off from the inner cord and receives the intercosto-humeral nerve which is the lateral cutaneous branch of the second dorsal. Together these nerves supply with cutaneous branches the floor of the axillary space and the inner side of the arm. The lesser internal cutaneous originates from the first dorsal segment.

The internal cutaneous nerve is given off from the inner cord and originates from the eighth cervical and first dorsal segments. It supplies with cutaneous branches the lower and inner part of the arm and the anterior half and posterior third of the forearm on the ulnar side.

The inner cord is continued as the ulnar nerve which originates from the eighth cervical and first dorsal segments. It passes through the arm without giving any branches, continues its course posterior to the elbow-joint, being found in a groove between the internal condyle of the humerus and the olecranon process of the ulna. In the forearm, it supplies one and one-half muscles on the anterior surface, then passes to the hand where it supplies fifteen and one-half muscles and gives off cutaneous branches to the palmar and dorsal surfaces of the medial side of the ring finger and all of the little finger and corresponding part of hand.

The circumflex nerve is given off from the posterior cord and originates from the fifth, sixth and seventh cervical segments. It passes through the quadrilateral space and under the deltoid muscle.

It supplies the teres minor and deltoid muscles, the shoulder joint, and the skin over the deltoid.

The upper subscapular nerve is given off from the posterior cord and originates from the fifth, sixth and seventh cervical segments. It passes under the scapula and supplies the upper part of the subscapularis muscle.

The middle or long subscapular nerve is given off from the posterior cord and is from the fifth, sixth, seventh and eighth cervical segments. It supplies the latissimus dorsi.

The lower subscapular nerve is given off from the posterior cord and is from the sixth, seventh and eighth cervical segments. It passes under the scapula and supplies the lower part of the subscapularis and the teres major muscles.

The posterior cord continues as the musculo-spiral nerve, originating from all the segments of the plexus. It passes to the back of the humerus and supplies the triceps muscle, giving off between the two lower heads of the triceps the posterior cutaneous nerve. The posterior cutaneous nerve supplies the back of the arm and the posterior third of the forearm with cutaneous branches. The musculo-spiral is found at the outer side of the elbow-joint, where it gives off the radial nerve which passes thru the forearm to the hand to become the cutaneous nerve for the dorsal surface on the radial side, extending to one-half of the ring finger. In the forearm, the musculo-spiral gives off the posterior interosseous nerve which, with the main nerve trunk, supplies the twelve muscles on the posterior surface of the forearm.

Directly from the fifth, sixth and seventh segments, originates the posterior or long thoracic nerve which passes over the anterior border of the scalenus medius and down over the first rib to supply the serratus magnus muscle.

The scaleni and longus colli receive a part of their innervation directly from the fifth, sixth, seventh and eighth cervical segments.

The Dorsal Nerves

In the dorsal region there is a typical arrangement of the nerves with three exceptions, these being the first, second and twelfth. This somewhat regular distribution is called a TYPICAL SPINAL NERVE, (See Fig. 42, page 106), and this arrangement may be traced to the anterior primary divisions other than the dorsal. Along the course of the nerve a lateral cutaneous branch is given off, which divides into anterior and posterior branches. The nerve terminates near the midline anteriorly by dividing into an anterior deep muscular and an anterior cutaneous, with mesial and lateral branches.

The first intercostal nerve is a small part of the first dorsal segment, the greater part being used in the formation of the brachial plexus. This small nerve does not have a lateral cutaneous branch nor the two terminal anterior branches, but supplies the intercostal muscles of the first intercostal space only.

The second intercostal nerve gives off a lateral cutaneous branch which is known as the intercostohumeral nerve and joins with the lesser internal cutaneous of the brachial plexus. It may or may

not give off anterior muscular and cutaneous branches. Its anterior cutaneous branch maintains a balance with the descending cutaneous nerve of the cervical plexus in its distribution over the upper part of the thorax. It supplies the intercostal muscles of the second intercostal space.

The third, fourth, fifth and sixth intercostals each give off typical branches: the lateral cutaneous nerves, supplying the lateral wall of the thorax; the anterior cutaneous, supplying the anterior thoracic wall; and the anterior deep muscular, supplying the triangularis sterni muscle. It should be noted that the upper six intercostal nerves are confined in their distribution to the thorax.

The seventh to eleventh intercostal nerves are typical in their distribution except that they terminate in the abdominal wall and supply the external oblique, internal oblique, transversalis, rectus abdominis and pyrimadalis muscles, and their anterior cutaneous branches are for the supply of the anterior abdominal region.

The twelfth dorsal nerve divides into the subcostal and the dorso-lumbar nerve which assists in the formation of the lumbar plexus. The subcostal nerve is found below the twelfth rib and has a course similar to the preceding intercostals. It assists in the supply of the lateral abdominal wall through its lateral cutaneous branch which frequently passes over the crest of the ilium. Anteriorly, its distribution is the same as that of the lower intercostal nerves.

The Lumbar Plexus

The lumbar plexus is formed by the anterior primary divisions of the twelfth dorsal and upper four lumbar nerves. It lies in the substance of the psoas magnus muscle and is anterior to the transverse processes. Directly from the segments arise nerves that supply the following muscles: the psoas parvus by one from the first lumbar; the psoas magnus and iliacus by branches from the second, third and fourth; and the quadratus lumborum by branches from the upper four lumbar segments.

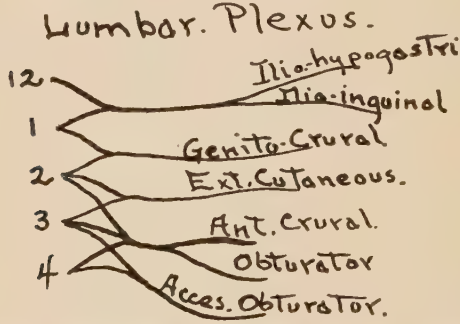


FIG. 62. Diagrammatic representation of the main branches of the lumbar plexus.

The ilio-hypogastric nerve originates from the twelfth dorsal and the first lumbar segments. It passes laterally behind the kidney and, entering the lateral abdominal muscles, supplies the external oblique, internal oblique, and transversalis. Its lateral cutaneous branch passes over the crest of the ilium and supplies the skin in the anterior gluteal region. It terminates anteriorly as a hypo-

gastric branch which is distributed to the skin in the hypogastric region of the abdomen.

The ilio-inguinal nerve originates from the twelfth dorsal and the first lumbar segments. It passes below the ilio-hypogastric, having a similar distribution to its terminal branch which passes down the inguinal canal to assist in the cutaneous supply of the upper and inner portion of the thigh and the external genitals.

The genito-crural nerve originates from the first and second lumbar segments. It descends along the anterior surface of the psoas magnus. Its genital branch supplies the cremaster muscles and terminates in the skin of the external genitals. The crural branch passes under Poupart's ligament and terminates in the skin of the upper and inner part of the thigh.

The external cutaneous nerve originates from the second and third lumbar segments. It passes along the lateral margin of the psoas magnus and over the iliacus to the notch below the anterior superior spine of ilium, leaving the abdominal region, by passing beneath Poupart's ligament. It then becomes the cutaneous nerve for the lateral portion of the thigh and extends to the knee-joint.

The obturator nerve originates from the second, third and fourth lumbar segments. It appears at the inner side of the psoas magnus, passes down into the upper and lateral part of the true pelvis and leaves it by passing through the obturator canal, and appearing then on the inner side of the thigh. It gives off an articular branch to the hip-joint and a small cutaneous branch to the inner side of the

thigh, and supplies the obturator externus, adductors brevis, longus and magnus, gracilis and occasionally the pectineus.

The accessory obturator, when present, originates from the third and fourth lumbar segments. It passes beneath Poupart's ligament and assists the obturator nerve in supplying the muscles on the inner side of the thigh.

The anterior crural or femoral nerve originates from the second, third and fourth lumbar segments. It emerges from the lateral border of the psoas magnus and passes beneath Poupart's ligament into Scarpa's triangle where it gives off its branches. The middle and internal cutaneous nerves, given off from the anterior crural, supply the anterior and internal surfaces of the thigh and pass to the knee-joint. The long saphenous nerve follows thru Hunter's canal with the femoral vessels, but pierces the fascia between the tendons of the gracilis and sartorius to supply the skin of the inner side of the leg and foot as far forward as the base of the great toe. The remaining branches of the anterior crural supply the sartorius, rectus femoris, vastus internus, externus and medialis, pectineus and subcrureus.

The Sacral Plexus

The sacral plexus is formed by the fourth and fifth lumbar, and the first, second and third sacral segments. The plexus is found in the pelvis and anterior to the pyriformis muscle.

The nerve to the quadratus femoris originates from the fourth and fifth lumbar and first sacral

segments. It leaves the pelvis thru the great sciatic notch below the pyriformis and supplies the gemellus inferior and quadratus femoris.

The nerve to the obturator internus originates from the fifth lumbar and the first and second sacral segments. It leaves the pelvis through the great sciatic notch below the pyriformis, crosses the ischial spine, supplies the gemellus superior, then enters the ischio-rectal fossa, where it supplies the obturator internus muscle.

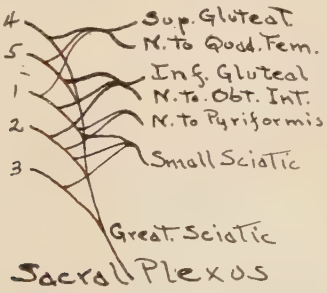


Fig. 63. Diagrammatic representation of the main branches of the sacral plexus.

The superior gluteal nerve originates from the fourth and fifth lumbar and first sacral segments. It leaves the pelvis, passing above the pyriformis muscle through the great sciatic foramen and supplies the gluteus medius and minimus and the tensor fascia lata.

The inferior gluteal nerve originates from the fifth lumbar and the first and second sacral segments. It leaves the pelvis below the pyriformis, passing through the great sciatic foramen and enters the gluteus maximus to supply it.

The nerve to the pyriformis muscle originates from the first and second sacral segments and passes immediately into its substance.

The small sciatic nerve originates from the first, second and third sacral segments. It is a cutaneous nerve throughout its distribution, gives off a pudendal branch, which passes to the anal region and to the external genitals. The gluteal branch passes over the lower margin of the gluteus maximus. The sural branch continues down back of the thigh as far as the knee-joint and occasionally passes below to the lower margin of the popliteal space.

The great sciatic nerve originates from the fourth and fifth lumbar and the first, second and third sacral segments. It leaves the pelvis, passing through the great sciatic foramen below the margin of the pyriformis muscle. In the thigh, it supplies the biceps femoris, semitendinosus and semimembranous and assists in the innervation of the adductor magnus. At the upper border of the popliteal space, it divides into the internal and external popliteal nerves.

The internal popliteal nerve passes through the middle of the popliteal space and, after giving off the communicans tibialis, supplies the popliteus, gastrocnemius, plantaris, and soleus muscles. The communicans tibialis joins with the communicans fibularis form the short saphenous nerve which is cutaneous to the back of the leg, the outer side of the ankle and the foot to the base of the small toe. After passing beneath the soleus, the nerve is known as the posterior tibial and as such gives off motor

branches to the soleus, tibialis posticus, flexor longus hallucis and flexor longus digitorum. At the inner side of the ankle, the nerve divides into its three terminal branches, the calcanean, internal and external plantar. The calcanean branch is cutaneous to the region of the heel. The internal plantar passes along the inner side of the plantar surface of the foot, supplying the skin in that region and four muscles of the foot. The external plantar nerve passes to the outer side of the plantar surface of the foot, supplying the skin in relation and the remaining sixteen muscles on the plantar surface of the foot.

The external popliteal nerve passes along the tendon of the biceps to the outer boundary of the popliteal space, pierces the peroneus longus and divides into its terminal branches, the musculo-cutaneous and anterior tibial nerves. It gives off in the popliteal space, a lateral cutaneous branch, which supplies the antero-lateral surface of the leg, and the communicans fibularis which joins with the communicans tibialis, forming the short saphenous nerve already described.

The musculo-cutaneous nerve passes down in the lateral compartment of the leg and supplies the peroneus longus and brevis. Passing from between the anterior margins of these muscles, it becomes cutaneous to the lower antero-lateral part of the leg, continues to the dorsum of foot, which together with the anterior tibial it supplies, and terminates in the supply of the toes.

The anterior tibial passes deeply in the anterior compartment of the leg and supplies the tibialis

anticus, extensor longus digitorum, extensor longus hallucis, and peroneus tertius. Passing into the foot along the dorsal surface, it supplies the extensor brevis digitorum and continues as a cutaneous nerve to the dorsum of the foot and toes.

The Pudendal Plexus

The pudendal plexus overlaps the sacral, being formed by parts of the second and third sacral segments and all of the fourth. Muscular branches are given off directly from the third and fourth sacral serments to the levator ani and coccygeus muscles. The external sphincter ani is supplied by a branch from the fourth segment.

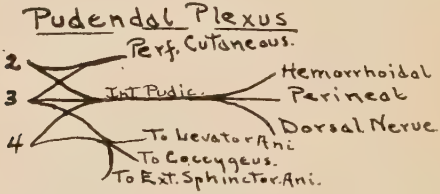


Fig. 64. Diagrammatic representation of the main branches of the pudendal plexus.

The perforating cutaneous nerve originates from the second and third sacral segments and, after perforating the great sciatic ligament, supplies the skin over the postero-inferior portion of the origin of the gluteus maximus.

The internal pudic, originating from the 2nd, 3rd and 4th sacral segments, is the largest nerve of the plexus and, after passing out of the pelvis thru the great sciatic foramen below the margin of the pyriformis, it turns around the ischial spine to enter

the ischio-rectal fossa where it divides into its terminal branches.

The inferior hemorrhoidal nerve assists in the supply of the external sphincter ani and is cutaneous in the anal region.

The perineal nerves supply the perineal muscles and those found in the uro-genital region, and also send cutaneous branches to the skin of the urogenital triangle.

The dorsal nerve to the penis or clitoris enters the deep perineal interspace and, reaching its apex, passes to the dorsum of the penis or clitoris, carrying cutaneous impulses.

The Coccygeal Plexus

This small plexus of nerves is formed by the fifth sacral and the coccygeal nerves, which join to form a single cutaneous nerve supplying the skin in the region of the coccyx.

CHAPTER X.

THE INVOLUNTARY NERVOUS SYSTEM

The involuntary nervous system, on account of its peculiar function and its many complexities, is the least understood of the three anatomical divisions we have made. In order to briefly describe this system and to picture it in such a way as to make it applicable to practice, it will be necessary to make a few preliminary remarks relative to its function and divisions.

First, let us consider the need of involuntary nerve impulses. We have in the body a quantity of involuntary musculature. In order for it to perform its function properly, it must have a normal nerve supply. This musculature is associated with the various systems of the body mainly derived from the mesoderm, and it is of great importance that this musculature be controlled perfectly, not only from a standpoint of contraction but also in the matter of relaxation. Thus we find in the innervation of involuntary muscle, we have to deal with accelerator and inhibitor impulses.

We also have associated with these systems a series of glands. In some cases the glands are controlled by certain chemicals found in the blood stream, but in other cases (by far more numerous)

the glands are controlled by the involuntary nervous system. Then, that which we wish to establish with reference to the involuntary nervous system is the origin of impulses that control the movements of involuntary musculature and the secretion of glands.

From a standpoint of origin, the involuntary nervous system will be divided into three parts; namely, the cephalic or vagus nerve, the thoracolumbar cord, and the pelvic nerve. It will be our purpose to take each of these in order and, following a brief anatomical description, state as nearly as has been determined the functions of each.

The Vagus Nerve

The vagus nerve belongs properly with the cranial series of nerves as to its anatomical position, but on account of its more important functions it, in reality, belongs to the involuntary nervous system. It carries, in fact, all kinds of impulses, that is, voluntary, involuntary and sensory. Inasmuch as these involuntary impulses originate with the deep origin of the nerve, they are part of the nerve itself and are not carried to the vagus from some other part of the involuntary nervous system.

The vagus nerve emerges from the side of the medulla and descends through the jugular foramen in company with the spinal accessory nerve. In the neck, it is found in the carotid sheath with the carotid artery and internal jugular vein. At the root of the neck, it passes into the thorax, being found mainly in relation to the œsophagus and passing with it through the diaphragm to end in the solar

plexus. Along its course, it gives off a number of branches, the function of which varies with the part supplied. Communications are established between the vagus and other nerves which are of importance also.

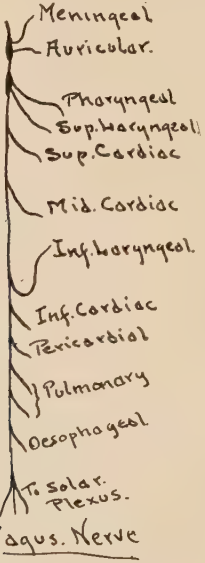


FIG. 65. The vagus nerve.

The facial nerve and vagus communicate by means of a branch which is associated with the ganglion on the root of the vagus. This accounts for the facial reflex noted, associated with disorders of the digestive tract especially.

The glosso-pharyngeal nerve receives a communicating branch from the ganglion of the root of the vagus which correlates movement between the muscles of the pharynx and those of the oesophagus.

The spinal accessory nerve receives a communicating branch from the ganglion on the trunk, through which the contractions of the sterno-mastoid are regulated in respiratory movements.

The hypoglossal nerve receives a communicating branch from the ganglion on the trunk which correlates movements of the tongue with those of the pharynx and oesophagus.

Communicating branches pass from both ganglia of the vagus to the superior cervical ganglion of the lateral chain, thus bringing the cephalic and thoraco-lumbar parts of the involuntary nervous system into close relation.

A communication exists between the vagus and the loop between the first and second cervical segments, which undoubtedly accounts for the irritation to the vagus, when lesions occur affecting either of these two cervical nerves.

The meningeal branch is given off from the ganglion on the root of the vagus and passes to the dura mater in the posterior cranial fossa. It is a sensory nerve, but may carry impulses to the deep origin of the nerve which will result in the activation of more distal branches.

The auricular branch is given off from the ganglion on the root of the vagus and is distributed to the external auditory canal. Irritation to this branch frequently results in ear cough or yawn, on account of the association with the branches to the larynx and to the nerves innervating the muscles opening the jaw. The auricular nerve is not only sensory to the canal, but also carries part of the glandular innervation to the ceruminous glands.

The pharyngeal branch is given off from the ganglion on the trunk and joins with the glosso-pharyngeal and superior cervical ganglion of the lateral chain and forms the pharyngeal plexus. Through this plexus, the vagus contributes sensory, voluntary-motor, and involuntary-glandular impulses to the pharyngeal wall.

The superior laryngeal nerve, given off from the ganglion on the trunk, passes down the neck for a short distance and then forward in relation to the greater cornu of the hyoid bone. It gives off the nerve to the crico-thyroid muscle, then passes thru the thyroid membrane, to supply the upper part of the inner surface of the larynx. It carries voluntary-motor impulses to the crico-thyroid and involuntary-glandular and sensory ones to the mucous membrane of the upper part of the larynx. The most common lesion affecting this branch is that of the hyoid bone, the nerve passing between the hyoid and the upper border of the thyroid cartilage.

The vagus gives off in the neck three cardiac nerves, which pass down into the thorax and join with the branches from the cervical ganglia of the lateral chain in the formation of the cardiac plexus. The impulses carried by the vagus are inhibitory nerves to the cardiac muscle, sensory and glandular to the pericardium.

Pulmonary branches are given off in the thorax which join with the pulmonary branches from the upper dorsal ganglion of the thoraco-lumbar cord and form the pulmonary plexuses. These plexuses send filaments to the lung, bronchial tubes

and trachea, carrying sensory, glandular, and involuntary-accelerator impulses.

The inferior or recurrent laryngeal nerves differ on the two sides. On the right side, the nerve passes anterior to the subclavian artery, then below and posterior to it, passing upward to the larynx between the trachea and oesophagus. On the left side, it passes into the thorax and anterior to the arch of the aorta, then inferior and posterior to the arch, passing upward between the trachea and oesophagus. It will be noted that the left recurrent laryngeal nerve is subject to lesions in the thorax, being irritated by pathology either of the arch of the aorta or of the left pleura near the apex of the lung. This nerve, after entering the lower part of the larynx, supplies the intrinsic musculature with voluntary impulses, and the mucous membrane with sensory and glandular impulses.

Oesophageal branches are given off from each vagus in the formation of an oesophageal plexus which supplies the oesophagus with sensory, voluntary-motor, involuntary-glandular, inhibitor and accelerator impulses.

The vagi pass through the diaphragm in company with the oesophagus and terminate in the solar plexus. From this distributing point, nerves are given off, following along the course of the branches of the abdominal aorta for the supply of the various organs. The vagus carries impulses to the structures as follows:

Cardiac end of stomach.—Involuntary-inhibitor, -accelerator, -glandular, and sensory.

Pyloric end of stomach.—Involuntary-accelerator, -glandular and sensory.

Pyloric valve.—Involuntary-inhibitor.

Small intestine.—Involuntary-accelerator, -glandular, and sensory.

Ilio-caecal valve.—Involuntary-inhibitor.

Liver.—Involuntary-glandular.

Gall Bladder.—Involuntary-accelerator and inhibitor.

Pancreas.—Involuntary-glandular.

The Thoraco-lumbar Cord

That part of the involuntary nervous system that has the greatest distribution is the thoraco-lumbar cord or more commonly called the lateral chain ganglia. Its *origin* is limited to the second dorsal to third lumbar segments, inclusive, but its *distribution* is unlimited, filaments being found in all parts of the body. By carefully analyzing this system, it will be seen to be as simple in its arrangement as any plexus of spinal nerves. It is on account of its many branches and connections with other nerves that it seems to be so complicated.

Histological examination of the anterior roots of the spinal nerves shows that from the second dorsal to the third lumbar, inclusive, a white fiber can be traced outward over the anterior primary division to a point where it leaves the main nerve and passes forward to terminate in the lateral chain ganglion found outside the spinal canal. These white fibers are called white rami communicantes and serve as the spinal origin of all the impulses transmitted over the lateral chain of ganglia. The first step, then, in the formation of this thoraco-lumbar

cord is its origin, as mentioned. Derived from these white rami we have the series of lateral ganglia that form chains on either side extending from the cephalic to the caudal extremities of the trunk, which are found to be connected in the cranium in relation to the anterior communicating artery by an inosculation of fibers, the ganglion of Ribes, and also connected at the caudal extremity, anterior

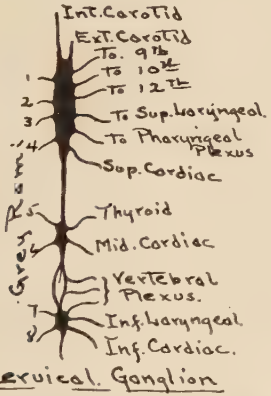


FIG. 66. The cervical ganglia of the thoraco-lumbar cord and branches.

to the coccyx, by the ganglion impar. The first branches of this lateral chain are grey rami communicantes, given off to each segment of the spinal cord making altogether thirty-one pairs for the two sides. Thus we see that the white rami are carrying impulses away from the cord, while the grey rami carry impulses back to the cord or its membranes and arteries. Other branches are given off in the various regions, each of which necessitate a more detailed description.

In the cervical region there are three named ganglia, the superior, middle and inferior cervical, together with a ring of filaments found around the subclavian artery called the annulus of Vieussens. The superior cervical ganglion is the largest of the three and is found opposite the transverse processes of the second and third cervical vertebrae. It is in reality four fused ganglia that correspond to the upper four cervical segments.

This ganglion has a number of branches, and an upward extension of it passes into the cranial cavity to join with a similar extension of the opposite side and to terminate, as already described, as the ganglion of Ribes.

Grey rami communicantes are given off to the upper four cervical nerves. After joining with the cervical nerves, these filaments are distributed as follows: some pass back into the spinal canal and supply the dura mater and the wall of the arteries, supplying the spinal cord; some pass out over the posterior nerve root, carrying sensory impulses to the cord; others are distributed with the anterior and posterior primary divisions of the spinal nerves. This plan of distribution of the impulses carried by the grey rami is constant thruout the thirty-one segments of the cord, because, as heretofore stated, each segment receives a grey ramus which has a systematic distribution thruout the entire series. We are thus able to trace readily the involuntary impulses to the skin and to other structures supplied by named nerves derived from spinal segments, but receiving involuntary impulses.

Communicating branches are given off joining the glosso-pharyngeal, vagus, hypoglossal and the superior laryngeal branch of the vagus. These contribute involuntary impulses, carried to the periphery by the nerves named.

A pharyngeal branch is given off which passes to the outer wall of the pharynx and with the vagus and glosso-pharyngeal forms the pharyngeal plexus from which the impulses are carried to the pharynx.

The superior cervical cardiac nerve is a branch of this ganglion and passes down in the neck to end in the cardiac plexus. It carries involuntary-accelerator impulses to the heart.

The external carotid branch follows along with the external carotid artery and is distributed to the wall of that artery and its branches. A branch from the nerves of the facial artery passes to the submaxillary ganglion of the mandibular branch of the trigeminal nerve as its involuntary root. Another branch, given off from the nerves of the middle meningeal artery, is called the smallest superficial petrosal and passes to the otic ganglion as its involuntary root.

The internal carotid branch is the upward cranial extension of the superior cervical ganglion and follows with the internal carotid artery into the cranial cavity. In the cavity, it breaks up into two named plexuses, one found lateral to the artery and called the carotid plexus, the other lateral to the cavernous sinus and called the cavernous plexus. These two, while separated, are intimately connected by many fine fibers passing back and forth. From these two plexuses, branches are given off to

adjacent structures and all carry some form of involuntary impulse. From the carotid plexus, the following are given off: carotid branches to the artery and its branches; communicating branches to the abducens nerve and to the Gasserian ganglion of the trigeminal nerve; the great petrosal which, with the great superficial petrosal nerve from the facial, forms the Vidian nerve, passing to Meckel's ganglion, associated with the maxillary division of the trigeminal. The small deep petrosal nerve passes to the tympanic plexus in the middle ear and is there associated with the glosso-pharyngeal nerve.

The cavernous plexus contributes the following branches: communicating branches to the oculo-motor, trochlear, and ophthalmic branch of the trigeminal nerves; a branch to the ciliary ganglion, as its involuntary root; and branches to the pituitary body.

The middle cervical ganglion, found between the transverse processes of the fifth and sixth cervicals, gives off grey rami to the fifth and sixth cervical segments, their distribution being the same as mentioned above in connection with the general distribution of grey rami.

The middle cervical cardiac nerve is given off from this ganglion and carries to the heart involuntary-accelerator impulses.

A branch is given to the inferior thyroid artery which follows it into the substance of the thyroid gland.

The annulus of Vieussens is found around the subclavian artery and between the middle and infer-

ior cervical ganglia and gives branches to the subclavian artery and to the phrenic nerve.

The inferior cervical ganglion lies between the transverse process of the seventh cervical vertebra and the neck of the first rib. It gives off grey rami to the seventh and eighth cervical segments. The inferior cervical cardiac branch descends and terminates in the cardiac plexus, carrying involuntary-accelerator impulses. A branch is given off to the inferior or recurrent laryngeal branch of the vagus. The involuntary plexus, following along with the vertebral artery, is derived from this ganglion also, and may be traced into the cranial cavity with it.

The thoracic series of ganglia vary in number from ten to twelve and form a chain with their connecting cords, found lateral to the bodies of the vertebrae, anterior to the heads of the ribs, and posterior to the pleura. Grey rami communicantes are given off to each of the twelve thoracic nerves.

Pulmonary branches are given off from the second, third and fourth ganglia, which pass to the pulmonary plexus and carry inhibitory impulses to the musculature of the bronchial tubes.

Aortic branches are given off from the upper four or five ganglia and inosculate around the thoracic aorta, sending twigs to each branch and carrying impulses to the wall of the arteries.

The great splanchnic nerve originates from the fifth to the ninth dorsal ganglia, inclusive, and passes along the antero-lateral aspect of the lower dorsal bodies, piercing the crus of the diaphragm and terminating in the solar plexus.

The lesser splanchnic nerve originates from the tenth and eleventh dorsal ganglia and, following a course similar to the great splanchnic, terminates in the solar plexus.

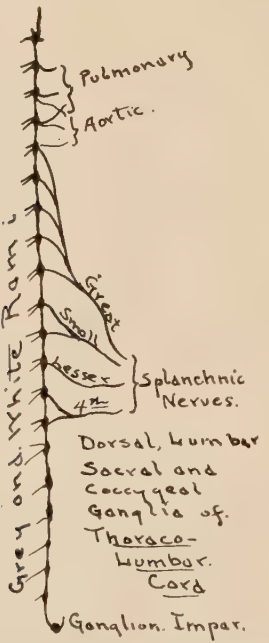


FIG. 67. The dorsal, lumbar, sacral, and coccygeal ganglia of the thoraco-lumbar cord and branches.

The least splanchnic nerve arises from the twelfth dorsal ganglion and passes through the diaphragm into the solar plexus or the renal plexus.

In connection with the distribution of the vagus nerve, it was mentioned that it also enters into the formation of the solar plexus, and, from this large

distributing point, branches are given off to various viscera in the abdominal cavity. The thoraco-lumbar cord follows the same plan through its splanchnic branches, these being eventually distributed by following the arteries to the viscera, not only of the abdominal region, but also to the pelvic region.

The lumbar ganglia are usually four in number and are found nearer the midline than the dorsal, and mesial to the margin of the psoas magnus muscle. Grey rami are given off to each of the lumbar segments and are the longest to be found, having to pass under the fibrous arches of the origin of the psoas muscle. Branches are given off to join with branches of the solar plexus in the formation of the hypogastric nerve which sends impulses to the pelvic plexus, found lateral to the rectum.

The sacral ganglia are usually four in number and lie anterior to the sacrum and mesial to the anterior sacral foramina. The two cords converge distally to join in front of the coccyx in the formation of the single coccygeal ganglion or ganglion impar.

Grey rami are given off from the sacral nerves, these being the only branches.

In consideration of the great distribution and complexity of the thoraco-lumbar cord, it is well to take it up now from a standpoint of function, and divide the impulses into dermal, visceral, vascular and glandular.

The skin, on account of having within it glands and involuntary muscle, needs involuntary nerves. These accompany the various cutaneous

branches of the spinal segments and, in the region of the face, the trigeminal. The trigeminal receives impulses from the thoraco-lumbar cord thru the branches mentioned, associated with the Gasserian, ciliary, otic, spheno-palatine and submaxillary ganglia. Each of the spinal nerves receives from the thoraco-lumbar cord a grey ramus. Thus it will be seen how these pilo-motor and glandular impulses reach the skin from the thoraco-lumbar cord. The entire dermal involuntary innervation is derived from this part of the involuntary nervous system.

The respiratory tract receives through the pulmonary plexus involuntary-inhibitory impulses, these arising from the second, third and fourth dorsal ganglia.

The distribution to the digestive tract through the solar plexus is as follows:

STOMACH, PYLORIC END.—Inhibition.

PYLORIC VALVE.—Acceleration.

SMALL INTESTINE.—Inhibition.

ILIO-CAECAL VALVE.—Acceleration.

LARGE INTESTINE.—Inhibition.

INTERNAL SPHINCTER ANI.—Acceleration.

To the genital tract the following impulses are carried:

FALLOPIAN TUBES.—Acceleration and inhibition.

UTERUS.—Acceleration and inhibition.

VAGINA.—Acceleration.

VAS DEFERENS.—Acceleration and inhibition.

PROSTATE MUSCULATURE.—Acceleration.

To the urinary tract the following:

URETERS.—Acceleration and inhibition.

BLADDER.—Inhibition.

URETHRAL SPHINCTER.—Acceleration.

The heart receives through the cardiac branches of the cervical ganglia impulses of acceleration. The arteries of the body are controlled entirely by the thoraco-lumbar cord, receiving both accelerator and inhibitor impulses from this region. THIS IS A MOST IMPORTANT FACT TO NOTE, THAT THE BLOOD SUPPLY OF EVERY STRUCTURE IN THE BODY IS CONTROLLED BY NERVES HAVING THEIR ORIGIN IN THE DORSAL AND LUMBAR REGIONS.

Glands found in the region of the head and associated with the nose, mouth and pharynx are partly supplied by the thoraco-lumbar cord. Also those glands at the caudal extremity of the trunk, associated with the genito-urinary systems, are partly supplied by this same cord.

The Pelvic Nerve

Passing out of the second, third and fourth sacral foramina and associated with the sacral nerves, we find the last division of the involuntary

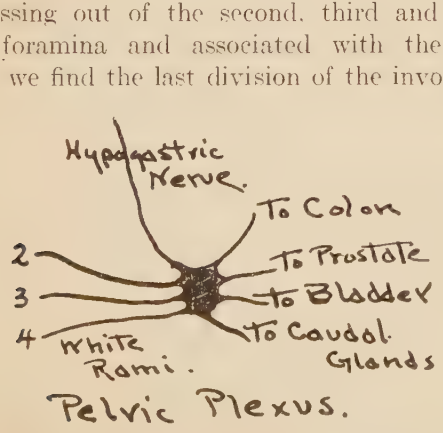


FIG. 68. The pelvic nerve plexus, and branches.

nervous system. These white rami communicantes do not pass into the formation of the lateral chain ganglia, although they are closely associated with them. They form, together with the hypogastric nerve, a plexus in the pelvis called the pelvic plexus, one being found on either side of the rectum. From this pelvic plexus, we have visceral and glandular impulses given off as follows: completing the innervation of the digestive tract, we find the colon thruout its entire extent receiving accelerator impulses, the ilio-caecal valve and internal sphincter ani receiving inhibitor impulses; the musculature of the prostate gland receives accelerator impulses; the urinary bladder receives accelerator impulses, and the urethral sphincter inhibitor impulses; glands, associated with the genito-urinary system and derived from the entoderm, are innervated partly by the pelvic nerve.

DR H.V HALLADAY, OF KIRKSVILLE, MO, DEMONSTRATING BY MEANS OF A DARK BROWN SKELETON. IT WAS A GREAT RELIEF FINALLY TO LEARN THAT THE THING HAD BEEN THE FRAMEWORK OF A COLORED MAN, THUS WAS ITS COLOR ACCOUNTED FOR.

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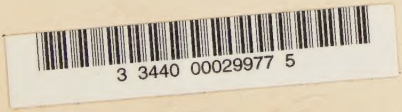
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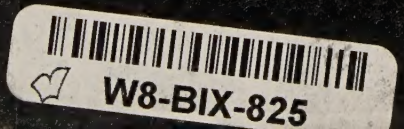
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